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From the Editor

Education is one of the basic needs of mankind. Everyone has a right to equal opportunity to education. So does that mean everyone has the right to study medicine or engineering or management? Why do schools in developed countries set such high qualifying requirements that most applicants fail to get admitted? At first glance such restrictions appear to contravene the principle of right to education.

Since the past few years, Nepali students are a privileged lot. Because of the mushrooming of engineering, medical and management schools, anyone can now become an engineer, doctor or an MBA graduate, provided they can afford the relatively high fees. For every school that refuses admission to a student, there are ten others, which are ready to admit him. Today higher education in Nepal is no more elitist; it has become quite egalitarian.

So does this bode well for the country? Yes and no. In the past only a very small percentage of top students were provided scholarships for higher studies in foreign countries. The country always had a shortage of trained professionals. Today a much larger percentage of deserving students get to study the subject of their choice. More graduates means saturation of the market in Kathmandu and gradual filter down to other towns and rural areas of the country.

One of the downsides of the uncontrolled growth in the number of professional schools is the deterioration in the standard of education. Students with very little aptitude for science and mathematics are easily admitted into engineering courses. The students are in turn hardly motivated to excel because of the ease with which they have gained entry into the schools. This has resulted in the production of low quality professionals. This situation is perpetuated by the laissez faire attitude of the government. It is said the free market economy eventually rectifies anomalies of the market. Let us hope this happens soon and only high quality students compete and gain entry into professional schools as in the developed countries.

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ENERGY CONSERVATION IN BUILDINGS ; PROBLEMS AND PROSPECTS IN THE NEPALESE CONTEXT.

*Mukunda Shyam Ranjit**

1. Background / Introduction

Energy has always been an indispensable element in the life of human society. The major energy consuming sectors in the world are industry, transportation and buildings. Energy consumption in buildings extends over various phases, from the production of construction materials and transportation to the sites, to the use of energy during its lifetime. The energy consumed by the building during its life span refers to supply of light, heat and for other uses to meet the thermal comfort of the inhabitants as well as for the various works performed. The energy consumption pattern varies with the climate of the place and the building type. In a given climate for any building type, energy usage varies from building to building depending upon the size, shape, orientation, space planning, envelope design, choice of technology adopted, air conditioning system, lighting systems, operation and maintenance schedules, user's habit, etc. In developed countries a major chunk of the energy consumption in a building goes towards maintaining a comfortable thermal environment for the inhabitants while in developing countries like Nepal, the concept of energy conservation will help to uplift the living standards of the people. It is generally felt that the unit of energy saved is a unit of energy produced. So great importance should be given to the idea of energy conservation as this energy saved can be utilized for other necessary purposes. Hence, energy efficiency and conservation should be promoted in the building sectors too. It has been found that 10 – 15 % of energy can be saved through efficient building design alone. Hence various measures of energy conservation should be adopted and considered right from the design stage of the buildings.

2. Principles of Energy Conservation

The main purpose of energy conservation in buildings is to reduce power consumption without creating uncomfortable environment. The energy consumption measures need to be based on the study of energy consumption pattern, analysis of climatic data, and determination of acceptable comfort levels of the occupants. The large amount of energy used to maintain the comfort level of building can be minimized through proper design and construction of the buildings. The most important aspects from the thermal point of view for the energy conservation are:

- Lowering the heat losses and gain of the building through appropriate building design and construction techniques.
- Providing optimum natural ventilation requirements.
- Using passive concepts in building design
- Using thermal insulation to avoid heat losses
- Appropriate building orientation and shading
- Proper sizing and orientation of the fenestration installed.

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3. Strategies for Energy Conservation in Buildings.

Strategies for energy conservation in buildings can be adopted during various stages of the building, such as design stage, construction stage, operation & maintenance stage and salvation stage i.e. scrap and post utilization stage. One of the most important strategy for effective energy conservation in buildings is the formulation of comprehensive regulatory control measures by governments. The government can positively influence to bring about efficient energy use in buildings other than the building users' awareness on how important a role energy conservation plays in helping to conserve energy to a great extent. The selection of site, building design, orientation, insulation used, size of fenestration, lighting, various active and passive solar methods adopted, landscaping etc. can affect the performance of the building in terms of energy consumption and conservation. Besides these facts, transportation of materials, energy values of the materials production etc influence the amount of energy that the building uses.

4. Appropriate Technology Transfer and Adaptation of Innovative Ideas:-

Not only the architects and other technicians involved in the building trade and practices but also the government agencies and authorities should be well trained and informed about the necessity of energy conservation in buildings, not only for the immediate surroundings and objectives but also for the holistic need and global purposes. The innovative developments in materials, technology and research findings should be accessible to all the concerned agencies and proper networking should be developed in this aspect. Since the building occupants are the major end users of all kinds of energy sources, systems and projects, the increased efficiency, management options and conservation measures adopted in buildings will definitely increase the overall plant/system efficiency. The local authorities should be really strict in formulation and implementation of building regulations and strategies with energy conscious approaches. Mainly the following three steps need to be formulated:

I. Design Relevant Measures and Techniques

The information and data necessary for the architects and designers at the design and concept development stages such as site planning, orientation, landscaping, use of shading devices etc. need to be provided at the earliest stage of the project conceptualization. This sort of information should be easily accessible and made available freely. GIS information and facilities, though strategic in the modern context, should be available through proper networking and control system.

II. Appropriate Energy Efficient Technology

Proper evaluation of technology to be adopted and disseminated should be done by the concerned authorities. Blind adaptation and duplication of such high impact technology should be controlled. Proper documentation and research including evaluation is necessary. In this connection the study and evaluation of already implemented systems and technology is recommended.

- Hence study of traditional building technology, insulation techniques etc in various aspects should be promoted.
- Design and construction of proper wall system (thermal) with a desired U-value for the region should be determined. In the present scenario, composite wall system rather than heavy and thick external walls as in the traditional system, should be considered as a possible solution. This is where the concept of new building materials

and material science and construction technology meet and need vigorous exercise and research for the specific purpose as well as technology transfer to developing countries.

III. Innovative Ideas and Elements

Passive heating and cooling systems including ideas such as Trombe walls, solar chimney, thermal storage roofs, earth air tunneling, earth sheltering/berming, wind tower etc. should be considered by the designers as per necessity based on the judicial judgment on specific areas/region and the government rules and regulations should promote the inclusion of such items/ideas in building projects with necessary technical and financial assistance.

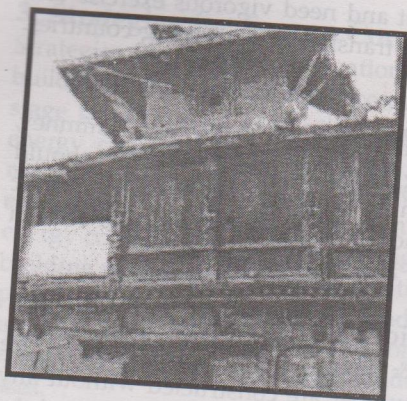
5. Energy Consumption in Various Types of Residential Buildings in Nepal:-

In Kathmandu valley (including Bhaktapur, Lalitpur & Thimi) about 10,000 houses are constructed every year. It is found that more than this number are constructed without any official recordings and permission from the concerned authorities in the rural areas of the valley. About 8,000 housing/construction permits are given every year. Recently, due to the on-going Maoist insurgency and political unrest, this population migration to Kathmandu valley and other urban areas has increased many folds than the usual urbanization rate. Hence the number of housing construction and demand for new housing system and numbers has increased very sharply. In general the buildings require electrical supply for lighting, space heating and air conditioning, cooking etc. Due to the climatic conditions the residential buildings require heating especially during winter months (lasting 3-4 months - Oct, Nov, Dec & Jan) and summer time air conditioning and electrical fan operation. The traditional buildings due to their building characteristics and material adaptation are found to be more energy efficient and climatically responsive than the new upcoming structures. Historical buildings have heavy thermal mass with small openings whereas the new buildings have reduced thermal mass with increased opening areas favoring daytime solar gain but neglected performance during night time. In this context our present generation is financially handicapped to build buildings and houses as good as the old ones. If the buildings are well designed, then especially the electrical energy for space conditioning, daytime lighting, and ventilation system can be reduced. Moreover the demand for firewood, coal, LPG gas can definitely be reduced and saved.

A building well designed with proper ventilation, day lighting, passive technology with proper thermal mass storage system can reduce the overall energy demand in the society. The frequent load shedding trends in the valley in winter months will not disturb the regular working habits/output of the people.

6. Case Studies

I. It's an old traditional building with an integrated courtyard which is an essential feature of a traditional settlement in Nepal. The building is made up of traditional materials with burnt brick external finishing and mud bricks used in a composite way in the internal part of the wall section. The inside surface is provided with lime and mud plastering and the inner height of the room is usually below 1.80 m. The structure is provided with a limited number of windows and openings. This kind of building has heavy thermal mass, is small in volume due to reduced height and is provided with small openings in limited numbers. The building is found to be thermally very efficient and comfortable both in the summer as well as in the winter. The U-value of the wall is about 0.95 – 1.05 W/m₂K.



A Traditional Building



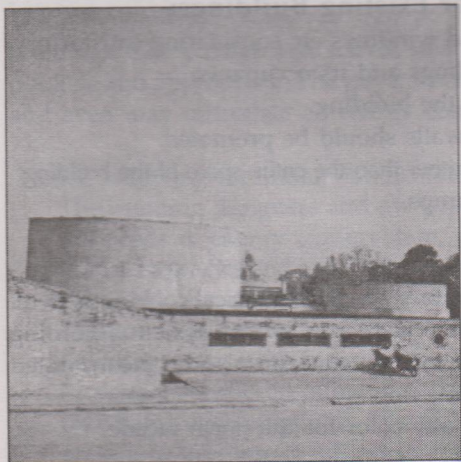
A typical traditional type of composite wall section.

II. It's a normal type of residential building nowadays coming up haphazardly all over Nepal. The structure is normally made of RCC construction with heavy concrete flooring. The walls are externally exposed brickwork and occasionally provided with cement plastering on the inside face. The walls are hardly 115 mm thick and rarely 230 mm thick. The inside height of the room is usually 2.70 m with increased inside volume. The openings are large compared to the traditional buildings. The usual practice is to provide 1.20 m x 1.80 m windows in larger numbers. Such buildings are found to be very cold in winter needing external heating and unusually hot and stuffy in summer. The buildings are generally roadside facing and passive heating characteristics are generally neglected. This is where the bye-laws need to be revised for the energy conscious approach

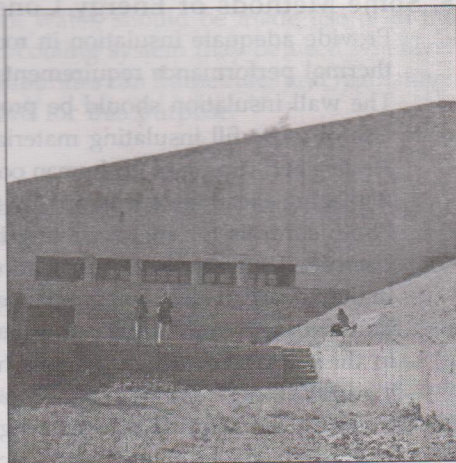


III. These are well designed experimental buildings by foreign architects. Some are found to be very good and architecturally sound. But energy performance-wise they need to be studied and monitored. In these buildings various items such as glass facade, solarium, earth berming, walls, floors, ceiling insulation have been integrated but architecturally found to be indigestible to the general public. The CEDA building at Kirtipur and a residential building designed by Ar. Paul Gut at Ekantakuna, Lalitpur fall in this category.

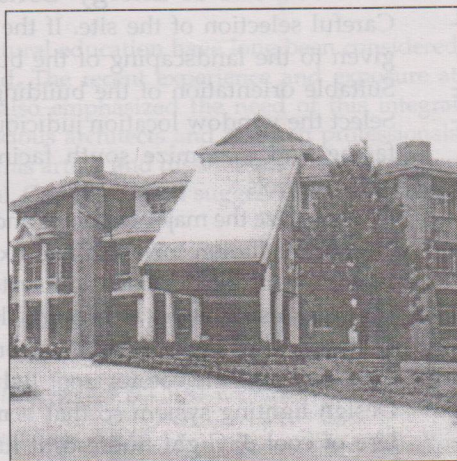
The buildings are highly functional and technology-wise sound and good but architecturally bold and unacceptable. Thermal performance-wise they are found to be good and satisfactory. Such structures need to be studied and monitored in detail and need further studies for finding a possible direction for further development.



CEDA Building at Kirtipur.



Residential Building designed by Ar. Paul Gut At Ekantakuna, Lalitpur.



Center for Energy Studies Building at Pulchowk.

7. Problems and Prospects in the Nepalese Context

Though at present it's generally experienced that the need of energy conservation in buildings is essential, there is hardly any concrete step being taken by the government nor are there any such plans in the long term. All the energy associates working in Nepal including REDP, ESAP, CES etc are interested in sectors other than buildings and related field. At present there are 57 municipalities in Nepal and Kathmandu Metropolitan City should especially consider seriously to review its building permits with energy conservation measures. All the large buildings, including tourism sector buildings, should be allowed to be constructed only after properly reviewing the design based on energy conservation principles and measures. New settlements and housing projects should be developed with RET and appropriate technology. A vast amount of energy can be saved and utilized for other constructive purposes if we start making our buildings more energy conscious and efficient. Moreover, the associated pollution can also be controlled.

8. Some Methods of Energy Conservation for Existing Buildings:-

- Provide adequate insulation in roofs, walls, and windows etc considering satisfactory thermal performance requirements of the buildings and its occupants.
- The wall insulation should be provided inside the building.
- Use of loose fill insulating materials in cavity walls should be promoted.
- Heating and cooling of the human occupied space rather than the entire space of the building.
- Replacing incandescent lamps by fluorescent lamps.
- Photo controls for energy saving in lighting.
- Use of solar water heater instead of geysers.
- Judicious use of electrical appliances like refrigerators, TV, and electrical cooking system.
- Retrofitting the building using one of the passive heat gain or loss system according to the climatic condition. Active heating or cooling systems can also be incorporated for heat storage like in the walls and the concrete floors.
- Coloring the south façade with light paint and any color for the north façade.
- Using light colors internally to increase the level of illumination.

9. Some Methods of Energy Conservation for New Buildings.

- Careful selection of the site. If the site has already been selected, emphasis should be given to the landscaping of the building complex and the building orientation.
- Suitable orientation of the building and the windows.
- Select the window location judiciously. Minimize the north facing, reduce east and west facing and maximize south facing provided they are protected by overhangs and other controls.
- Double glaze the major windows and provide maximum shutters for insulation of windows.
- Higher insulation for roofs and exposed walls.
- Provide controlled ventilation system.
- Consider using stairs as cooling shaft in summer by providing roof level openings.
- Protect entries by locating them on the leeward side; use draught lobbies.
- Consider high clerestorey roof light to maximize natural lighting.
- Design lighting system so that it meets the demands of the users.
- Use of cool daylight fluorescent tubes for supplying supplementary artificial lighting.
- Use of passive solar system for heating during winter.
- Temperature control and photo controls for energy saving in heating and cooling and lighting.
- Efficient design and maintenance of heating and cooling system.

9. Recommendations and Conclusion

A big amount of energy, including renewable as well as non-renewable energy, can be saved by making our buildings energy conscious besides providing a healthy living space. The buildings are one of the major sectors which consume a large amount of energy. So it's up to the designers of the buildings and the owners to conserve the energy needs of the building. Proper design of the building, awareness among the users, use of alternative fuel such as solar energy can help us to reduce the consumption of energy to a great extent.

Proper orientation and layout of the building can save a large amount of energy. Construction techniques, use of suitable building materials and guided approach can substantially effect conservation at the national level. While designing, appropriate selection of construction materials and equipment may be suggested for energy conservation purposes.

The non-conventional energy sources like solar, wind, water, should be made use of in the buildings. The passive and active solar heating and cooling system may be used wherever possible and appropriate. The government and local authorities can frame rules and regulations and even may formulate an energy conservation board for this purpose.

Hence following recommendations are made:

- The building designers and owners should be trained and provided with information on the needs of energy conservation, efficiency and management.
- Various agencies and stakeholders involved in construction activities, materials production etc should be made aware of the needs of energy conservation.
- The government and local authorities can frame rules and regulations and even formulate an energy conservation board for this purpose.
- Professionals should adopt a holistic approach while designing building projects rather than being concerned with financial returns only. Hence there should be some networking system to promote this kind of approaches.

Note from the Author:

Energy, built environment, building design and architectural education have long been considered in an integral way in eastern as well as western world. The recent experience and exposure at RENEWABLES 2004, Bonn Conference, Germany has also emphasized the need of this integral approach. The fruitful interaction with the energy conscious architects and research professionals at the Bonn conference has inspired the author to write this article and disseminate the information to fellow architects and students of architecture in Nepal. Comments and suggestions are welcome at ms1082004@yahoo.com.

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DEVELOPMENT OF GDP MODEL AND CONTRIBUTION OF NEPALESE CONSTRUCTION INDUSTRY IN ECONOMIC DEVELOPMENT

Prabhat K.C.*, Nabin Shrestha*

Abstract

The aim of this study is to develop GDP due to construction model and forecast for next five years. The GDP due to construction model is analyzed in MS-Excel program. The model is based on the multivariate econometric approach. The GDP due to construction model considers several factors such as number of registered contractors, number of registered manufacturing and service industries in construction, number of technical professionals, government investment in development, constructed road length, economically active population in construction as the model parameters affecting the GDP due to the construction sector. The user can select as many parameters as required for specific area and GDP due to construction model. The model can analyze the effects of several management measures such as material management, plant management, human resource management, financial management and time management on the GDP due to construction.

The developed model and forecast is applicable to Nepal. The correlation matrix is used to select the independent variables; their further acceptance in the model is based on the F-test and students' t-test and the goodness of fit of the model equation is assessed using maximum adjusted R^2 and minimum standard error criteria. Six different variables were used for the Construction Industry GDP model. The results indicated that number of registered contractors, number of registered large/medium manufacturing and services industries, number of technical professionals, government investment in development, road length for infrastructure development, economically active population in construction are the significant variables in GDP due to construction sector model. The elasticity of GDP due to construction with respect to technical professionals, government investment and road length are high in Nepal. The GDP due to construction model is capable of forecasting the GDP in construction sector and analyzing the effect of management measures. The log-log model is found to be the best in explaining the variation in the GDP due to construction sector for Nepal.

Keywords: Economic development, GDP, construction sector, Construction sector parameters

Construction activity constitutes a very important part of all planned projects and programs and leads to growth in a number of industries in the construction sector. These linkages generate income in addition to generating employment and boosting the rate of economic growth. The place of construction in the economics of several countries shows that between 1970 and 1985, the industry was responsible for over half of capital formation.

Construction also contributes a significant proportion to domestic products ranging from nearly 2 percent to over 10 percent. The industry is an important generator of employment varying from slightly less than 2 percent to nearly 20 percent. Several studies have analysed the role of

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construction in the economy from the point of view of its employment generating potential, its material input requirements and the impact of an expanding construction industry. The World Bank showed that the construction industry usually accounts for between 3 to 8 percent of a developing country's GDP.

The study was mainly based on secondary data, collected from various sources, such as publications of HMG offices, World Bank, ADB, Central Bureau of Statistics and National Planning Commission. The study is specially based on the economic sector. The accuracy of the result or the forecast depends on the quality and quantity of data available for each variable. In case of analysis of construction industries, due to the unavailability of old data, only 14 years data has been utilised. The time series data on different industries was not reliable because of the poor data keeping system and unsystematic bureaucratic system.

Functional Forms of the GDP due to Construction Model:

The most commonly used functional forms for a simple GDP due to construction models are the linear and double log. The linear and double log functional forms for a simple GDP due to construction model equations are:

$$1. \text{ Linear: } Q = a + b*(P) \quad \text{Equation1}$$

$$2. \text{ Double-log: } \ln Q = a + b*(\ln P) \quad \text{Equation2}$$

In many growth models, the estimated parameters are of primary concern and hence the statistical fit has been used to help discriminate between models, particularly between functional forms. The most common tactics is to examine t-values and measure of overall fit such as the F statistics or the coefficient of determination (R^2).

Identification of the Parameters

The general parameter affecting the GDP due to construction industries are identified based on the literature survey. The model equations are formulated with the selected variables that are logical and important. Hypothesis for all the variables are made according to the general acceptance with references to previous researches.

The following parameters are identified as the variables related to construction sector that affects the economic development of the country. From the literature review it was concluded that GDP of a country due to construction can fairly represent the contribution of the construction sector in the country's economy. The identified parameters that can change the GDP in construction (Y) are as follows:

1. Number of registered Contractors - X1
2. Number of registered Industries (Manufacturing and Services) - X2
3. Number of Technical Professionals - X3
4. Government Investment in selected development sectors in million Rs. - X4
5. Total road length in Km. - X5
6. Economically active population involved in construction sector - X6

Among the above listed parameters the most commonly used and most significant parameters are population that are economically active or the number of technical professionals as indicated by the results of past research in different places of the world.

Table 1 Data of Nepal from 1990 to 2003

Fiscal Year	Y	X1	X2	X3	X4	X5	X6
1990/91	11078.00	1254	5	1837	6725.50	8328	32497
1991/92	14769.00	1492	8	1952	10052.60	8851	35658
1992/93	17318.00	1071	3	1831	10830.80	9293	60734
1993/94	19621.00	1292	12	2039	11802.70	9664	85810
1994/95	23093.00	1261	18	2268	12039.30	10724	110886
1995/96	26093.00	1243	14	2080	15860.30	11237	135962
1996/97	29263.00	1134	14	2029	18444.40	11714	161038
1997/98	30483.00	1210	10	2112	19130.90	13223	186114
1998/99	33262.00	1274	26	1974	19000.50	13709	211190
1999/00	37382.00	1279	17	2250	20518.20	15308	236266
2000/01	39584.00	1276	10	2636	23134.40	15702	261342
2001/02	42247.00	1262	5	3267	18389.80	15985	286418
2002/03**	44470.00	1280		3987		16000	

This table shows the data collected from central government offices for the year 1990 to 2003. After using the statistical tools, the final model equations are:

1) Linear:

$$Y = -10471.281 - 0.21 * (X1) + 160.96 * (X2) + 6.54 * (X3) + 0.664 * (X4) + 1.67 * (X5)$$

Equation 3

2) Log-Log:

$$\ln Y = -0.9361 - 0.589 * \ln(X1) + 0.0866 * \ln(X2) + 0.6245 * \ln(X3) + 0.5508 * \ln(X4) + 0.5326 * \ln(X5)$$

Equation 4

The sign for all the variables are as expected except for X1.

Here, the Log-log model is better than linear model in terms of adjusted R² and standard error. The hypothesis was that the GDP due to construction increases with the increase in government investment in the development sectors, the increase in road length, the increase in technical professionals, and increase in the number of manufacturing and service industries. The result is quite significant.

The GDP due to construction in Nepal is mostly affected by the number of technical professionals, the government investment and road length. The main affecting parameter is government investment in the selected development sector. The above log-log model shows that 1% increase in the number of technical professionals increases the GDP of Nepal due to construction by 0.62%. Also 1% increase in government investment increases the GDP due to construction by 0.55%. The elasticity of GDP due to construction with respect to X4 is around 0.55 as reflected by the coefficient for X4 in the Log-Log model.

For the number of manufacturing and service industries, the sign is positive as expected. It is obvious as the increase in the number of industries drastically affect the GDP of Nepal due to construction. The elasticity of GDP due to construction with respect to the number of

manufacturing and service industries is 0.086. Hence 1% increases in the number of manufacturing and service industries will increase the GDP due to construction by 0.086% in Nepal.

Similarly, the elasticity of GDP due to construction with respect to the road length is 0.52. This shows that 1% increase in the road length will increase the GDP due to construction by 0.52%.

Table 2 Observed and Predicted GDP due to Construction for 1990-1999

Fiscal Year	Observed Y(MRs.)	Predicted Value of Y (GDP due to Construction in MRs.)	
		Linear	Log-log
1990	11078.00	11687.649	11584.301
1991	14769.00	14290.95	14580.876
1992	17318.00	16985.049	16728.449
1993	19621.00	19466.58	19336.815
1994	23093.00	24081.61	23202.286
1995	26093.00	25732.74	25884.15
1996	29263.00	28698.409	29887.813
1997	30483.00	31025.61	31181.37
1998	33262.00	32961.349	31990.558
1999	37382.00	36961.209	36935.044

Table 2 shows the predicted values of the GDP of Nepal due to construction as obtained using the model equations 4.1 and 4.2 for the year 1990-1999. The observed values of GDP due to construction in these years are also shown in the table.

GDP due to Construction Forecast for 2000-2001:

To test the forecasting capability of the models, the above equation was used to forecast the GDP due to construction in the year 2000 to 2001 with the known values of the explanatory variables. The results so obtained are shown in tables below.

Table 3: GDP due to construction forecast for 2000-2001 using linear model

Forecast using the Linear model								
Fiscal Year	Observed Y	X1	X2	X3	X4	X5	Forecasted Y	% error
2000	39584	1276	10	2636	23134.4	15702	40778.25	3.017
2001	42247	1262	5	3267	18389.8	15985	41523.639	-1.712

Table 4: GDP due to construction forecast for 2000-2001 using Log-log model

Forecast using the Log-log model								
Fiscal Year	Observed Y	X1	X2	X3	X4	X5	Forecasted Y	% error
2000	39584	1276	10	2636	23134.40	15702	42229.153	6.682
2001	42247	1262	5	3267	18389.80	15985	40720.466	-3.613

The tables 3 and 4 show the value of the independent variables used to find the forecast for the year 2000-2001, along with the forecasted value of GDP due to construction using the model and the % error with respect to the observed GDP due to construction.

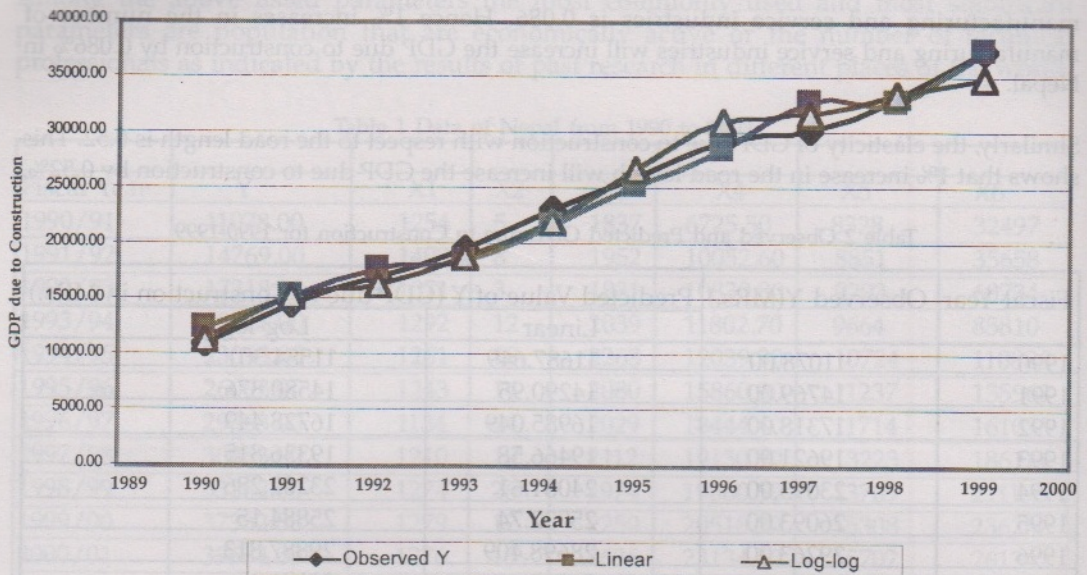


Figure 1: Observed and predicted GDP due to construction in Nepal

The above analysis with the data set of 10 years from 1990 to 1999 shows that the GDP due to construction is dependent on five factors namely; the number of registered contractors, number of manufacturing and service industries, number of technical professionals, government investment and constructed road length. And GDP due to construction has no significant effect on the other parameters of the preliminary selection. Through experience and the analysis of the GDP due to construction in other places by different researches, it is known that other parameters do have a significant effect on the GDP but the extent of effect differs from place to place. In fact the effect of the variables that are not present in the model equation but are somehow affecting the GDP due to construction is accounted for by the value of intercept.

Tables 3a and b shows that the forecasted GDP due to construction by model equations are satisfactory with error of less than 9% for the forecast in the year 2000 and 2001. Hence the model equations perform well to estimate the GDP due to construction in Nepal. The graph in figure is showing the GDP due to construction in different years with both the observed and the predicted values.

Among all the functional forms used, the log-log form is the best here with the highest R^2 and lowest standard error and also with the least % error in the forecasted GDP for the year 2000 and 2001.

Forecast of GDP due to Construction for 2004, 2005, 2006, 2007 and 2010

To forecast the GDP due to construction for the years to come, it is necessary to forecast the number of registered contractors, number of manufacturing and service industries, number of technical professionals, government investment and constructed road length in the forecast year as these are the explanatory variables that are present in the final model equations of GDP of Nepal due to construction. Similar methods are used to forecast the X variables. One of them is shown in detail.

Forecasting the Number of Registered Contractor

The increase in number of contractors in Nepal is a policy decision that has to be made by government according to the demand of the construction industry.

Using the trend of growth in the number of contractors and assuming that the contractors will increase in the same pattern, the number of contractors can be forecasted. For this a the best fit line and it's equation is obtained which can be any form such as linear, logarithmic, exponential, polynomial etc.

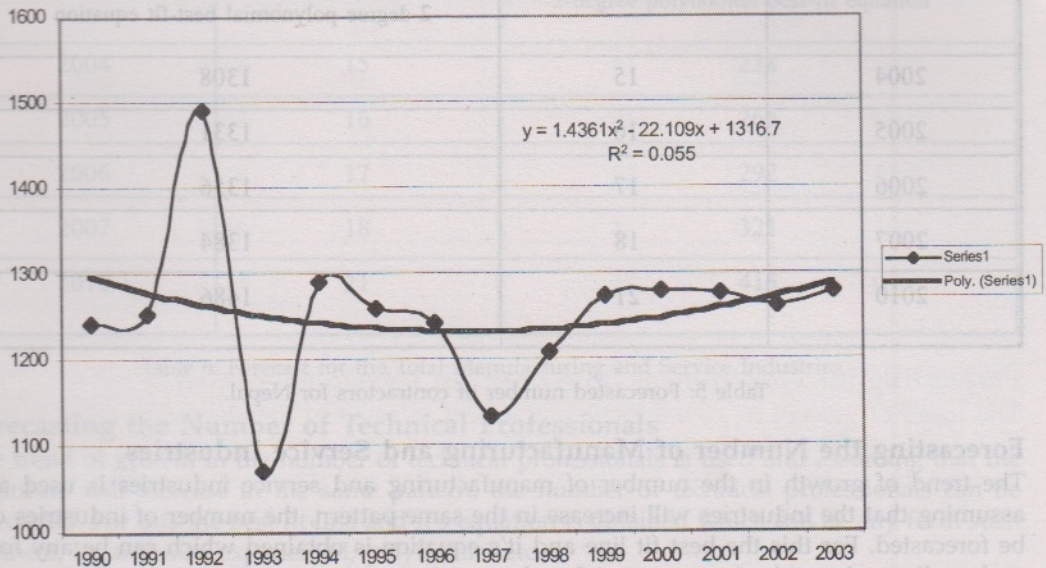


Figure2: Trend of the number of registered contractors in Nepal.

The best-fit equations so produced are as mentioned below.

Here $x=1$ for 1990, 2 for 1991, 3 for 1992 and so on.

That is; $x = ((\text{forecast year} - 1990) + 1)$

1) Linear

$$\text{Number of Contractors, } y = 51.443x - 101486 \quad \text{Equation 5}$$

($R^2 = 0.8245$)

This implies that every year the number of connection is increased by 53823.

2) Logarithmic

$$\text{Number of Contractors, } y = 102436 \ln(x) - 777208 \quad \text{Equation 6}$$

($R^2 = 0.8256$)

3) Exponential

$$\text{Number of Contractors, } y = 2E-77e^{0.092x} \quad \text{Equation 7}$$

($R^2 = 0.7056$)

4) 2-degree polynomial

$$\text{Number of Contractors, } y = -2.7594x^2 + 11034x - 1E+07 \quad \text{Equation 8}$$

($R^2 = 0.9392$)

So based on the highest R^2 criteria, the 2- degree polynomial equation as shown above is chosen to forecast the number of contractors in Nepal. The numbers of contractors in the forecast year are shown in table 5.

Year	X	Forecasted Number of Contractors using 2-degree polynomial best-fit equation
2004	15	1308
2005	16	1331
2006	17	1356
2007	18	1384
2010	21	1486

Table 5: Forecasted number of contractors for Nepal.

Forecasting the Number of Manufacturing and Service Industries

The trend of growth in the number of manufacturing and service industries is used and assuming that the industries will increase in the same pattern, the number of industries can be forecasted. For this the best fit line and it's equation is obtained which can be any form such as linear, logarithmic, exponential, polynomial etc.

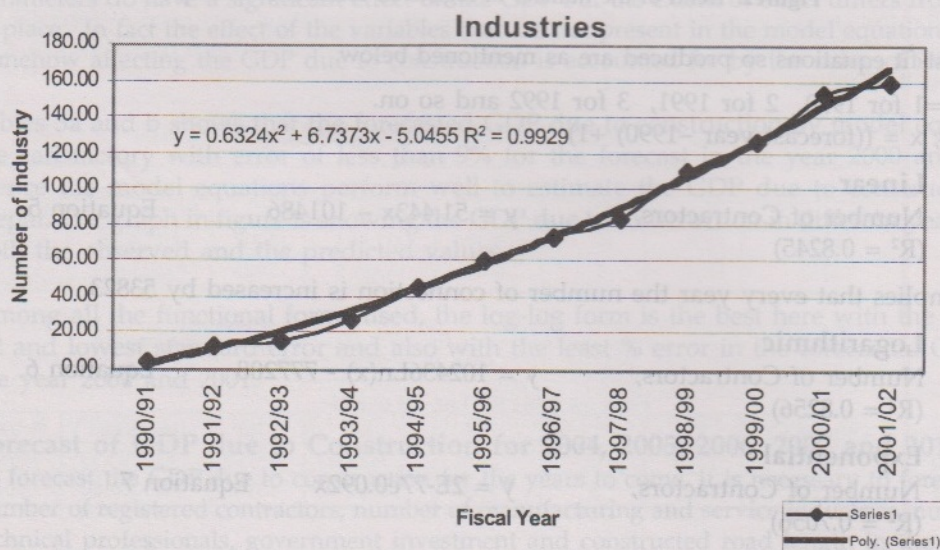


Figure3 : Trend line for the Total Manufacturing and Service Industries

Based on the highest R^2 criteria, the 2- degree polynomial equation as shown in the figure is chosen to forecast the number of industries in Nepal.

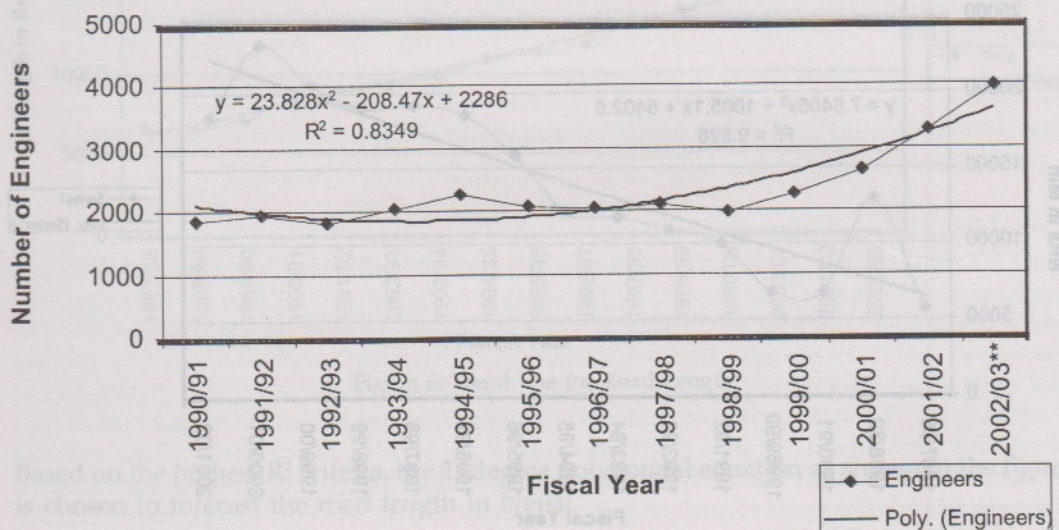
Year	X	Forecasted Number of Industries using 2-degree polynomial best-fit equation
2004	15	238
2005	16	265
2006	17	292
2007	18	321
2010	21	415

Table 6: Forecast for the Total Manufacturing and Service Industries

Forecasting the Number of Technical Professionals

The trend of growth in the number of technical professionals is used and assuming that the engineers will increase in the same pattern, the number of technical professionals can be forecasted. For this the best fit line and it's equation is obtained which can be any form such as linear, logarithmic, exponential, polynomial etc.

Number of Technical Professionals



Based on the highest R^2 criteria, the 2- degree polynomial equation as shown in figure is chosen to use for forecasting the number of technical professionals in Nepal.

Table 7 Forecast for the Technical Professionals

Year	X	Forecasted Number of Engineers using 2-degree polynomial best-fit equation
2004	15	4520
2005	16	5050
2006	17	5628
2007	18	6254
2010	21	8416

Forecasting the Government Investment in Development Sector

The trend of growth in government investment in selected development sector is used and assuming that the investment will increase in the same pattern, the government investment can be forecasted. For this the best fit line and it's equation is obtained which can be any form such as linear, logarithmic, exponential, polynomial etc.

Based on the highest R^2 criteria, the 2- degree polynomial equation as shown in the figure is chosen to forecast the government investment in development sector in Nepal.

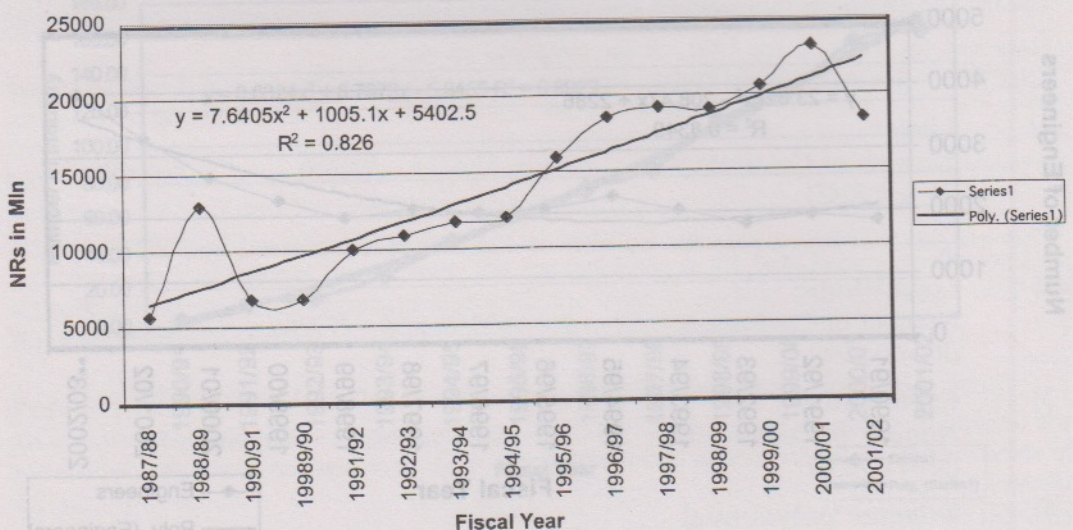


Figure 5: Trend line for Government Investment

Table 8 Forecast for Government Investment

Year	X	Forecasted Government Investment using 2-degree polynomial best-fit equation
2004	15	22198
2005	16	23440
2006	17	24697
2007	18	25970
2010	21	29879

Forecasted Road Length

The trend of growth in the road length is used and assuming that the road length will increase in the same pattern, the road length can be forecasted. For this the best fit line and its equation is obtained which can be any form such as linear, logarithmic, exponential, polynomial etc.

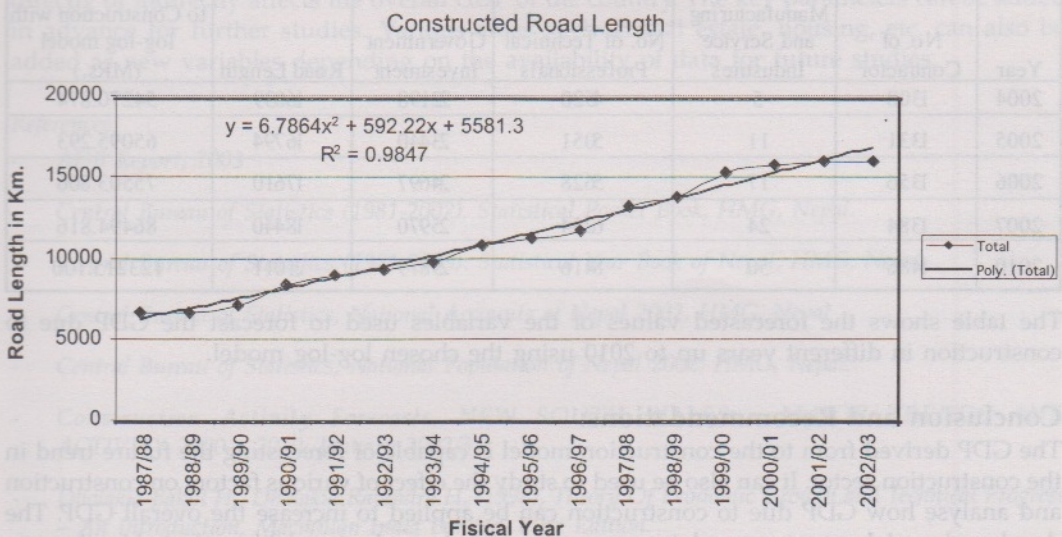


Figure 6: Trend line for Road Length

Based on the highest R^2 criteria, the 2- degree polynomial equation as shown in the figure is chosen to forecast the road length in Nepal.

Table 9 Forecast for Road Length

Year	X	Forecasted Road Length using 2-degree polynomial best-fit equation
2004	15	16039
2005	16	16794
2006	17	17610
2007	18	18440
2010	21	21011

Forecasted GDP due to Construction

Lastly the forecasted values of the variables are used to forecast the corresponding GDP due to construction.

Table 10: Forecasted GDP due to construction and variables for 2004, 2005, 2006, 2007 and 2010.

Year	No. of Contractor	No. of Manufacturing and Service Industries	No. of Technical Professionals	Government Investment	Road Length	Forecasted GDP due to Construction with log-log model (MRs.)
2004	1308	5	4520	22198	16039	54270.874
2005	1331	11	5051	23440	16794	65095.293
2006	1356	17	5628	24697	17610	75503.806
2007	1384	24	6254	25970	18440	86494.816
2010	1486	50	8416	29879	21011	123215.100

The table shows the forecasted values of the variables used to forecast the GDP due to construction in different years up to 2010 using the chosen log-log model.

Conclusion and Recommendations:

The GDP derived from the construction model is capable of forecasting the future trend in the construction sector. It can also be used to study the effect of various factors on construction and analyse how GDP due to construction can be applied to increase the overall GDP. The developed model can accommodate any number of independent variables selected by the user but there must be a co-relation and causality with the dependent variable (GDP due to construction). The multivariate econometric regression models are useful to assess the effect of various factors on GDP due to construction, if the reliable past records of the relevant model parameters are available. The forecasting capability of the multivariate model increases if the model equation is developed using more number of data set of the independent variables and the forecast is done for the short-term. Otherwise, the error in the forecast increases as the time gap between the data used in model equation development and the forecast year increases.

The most important variable in the GDP due to construction model are number of technical professionals, government investment and road length. The Log-log or Double log model is found to be the best among the most widely used functional forms, Linear and Log-log.

The accuracy of the GDP due to construction decreases as the time of forecast increases. This happens due to varying effects of several factors affecting GDP due to construction. Hence, to incorporate the changing scenario of the values of the independent variables and in turn the GDP, it is recommended to update the model equation as often as possible inclusive of the recent data and revise the forecasted values.

It is also highly recommended to collect reliable data of relevant parameters intensively to carry on this type of analysis, as it is totally dependent on the nature of the data set obtained. The upcoming new variables affecting the GDP due to construction should be introduced in updated analysis. In general, GDP due to construction is highly affected by time factor. So, to see the effect of time on GDP due to construction, it is better to analyse quarterly, using the monthly data.

The model should be updated with the available data up to the recent year before it is used in forecasting so as to get more accurate forecast in GDP due to construction. The GDP due to construction model analysis is useful at the utility level to plan the construction activities and investment for the future trend. The number of contractors, manufacturing and service industries are lagging. So, the government policy should be such that it should result in the increment of lagging areas. The number of construction projects should be increased which directly or indirectly affects the overall GDP of the country. The key parameters can be added in advance for further studies. Various areas such as real estate, housing, etc. can also be added as new variables depending on the availability of data for future studies.

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ISO 9001 QUALITY MANAGEMENT SYSTEM AND ITS APPLICATION IN ENGINEERING COLLEGES

Shailesh K. Singh*

ABSTRACT

Engineering colleges, like any other educational institution, are accountable to the public for their work in education. Almost all colleges also have formal quality assurance system in place, generally to show compliance of accreditation criteria. This quality assurance in engineering colleges serves the purpose of giving confidence to the stakeholders that the norms and requirements for quality education are being met continuously.

To achieve similar objectives in manufacturing and service sector, the ISO 9000 standards are being used for quite some time now. We are also aware of the benefits of these quality management system standards in these sectors. ISO 9000 standard, if implemented in an institution of higher education, will lead to a host of benefits and give a competitive edge to the institution; still not many institutions of higher education are implementing this international standard. Adoption of this standard provides the improvement pathways for organizations. This article aims to highlight the benefits and provide generic guidelines for incorporating these standards in engineering colleges offering undergraduate and graduate courses. The institutions offering research facilities are not directly considered here.

ISO 9000 FAMILY OF STANDARDS

ISO 9000 standards were first issued in 1987 by the International Organization for Standardization. The 1987 version of the ISO 9001 standard contained 18 clauses, which was revised in 1994 version to 20 clauses. The latest version of the standard ISO 9001:2000, which was released on 15th December 2000 has only five clauses for implementation. ISO 9000 is not just one standard, but a family of standards. The individual standards in this family are:

ISO 9000:2000 - Quality Management Systems - Fundamentals and Vocabulary

This International Standard describes fundamentals of quality management systems, which form the subject of the ISO 9000 family, and defines related terms.

ISO 9001:2000 - Quality Management Systems - Requirements

This International Standard specifies requirements for a quality management system where an organization needs to demonstrate its ability to consistently provide product (and/or service) that meets customer and applicable regulatory requirements, and aims to enhance customer satisfaction through the effective application of the system, including processes for continual improvement of the system and the assurance of conformity to customer and applicable regulatory requirements.

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All requirements of this International Standard are generic and are intended to be applicable to all organizations, regardless of type, size and product (and/or service) provided. This standard is used for certification purpose.

ISO 9004:2000 - Quality Management Systems - Guidelines for Performance Improvements

This international standard has been developed as a composite pair of ISO 9001:2000. It provides guidelines beyond the requirements given in ISO 9001 in order to consider both the effectiveness and efficiency of a quality management system, and consequently the potential for improvement of the performance of an organization. When compared to ISO 9001, the objectives of customer satisfaction and product quality are extended to include the satisfaction of interested parties and the performance of the organization.

This International Standard is applicable to the processes of the organization and consequently the quality management principles on which it is based can be deployed throughout the organization. The focus of this International Standard is the achievement of ongoing improvement, measured through the satisfaction of customers and other interested parties.

Another ISO standard, ISO 19001:2002, although not in the 9000 series but considered a part of the ISO 9000 family is relevant here.

ISO 19011:2002 - Guidelines for Quality and/or Environmental Management Systems Auditing

Applicable to both Quality and Environmental Management System, ISO 19011:2002 provides guidance on the principles of auditing, managing audit programmes, conducting quality management system audits and environmental management system audits, as well as guidance on the competence of quality and environmental management system auditors.

It is applicable to all organizations needing to conduct internal or external audits of quality and/or environmental management systems or to manage an audit programme.

BENEFITS OF IMPLEMENTING ISO 9001 QUALITY MANAGEMENT SYSTEM

Implementing any quality management system means spending a large sum of money. Till the benefits of implementing such a system is not clear, it is difficult that any institution will go for it. Before presenting the benefits, it is necessary to understand the present scenario in the field of education in general and engineering education in particular. Presently the environment for engineering colleges is no different from that for the business world. With the advancement in transport and communication facilities the engineering education has become truly global. Students have to compete in the international job market, putting pressure on the institution to keep up with latest technological trend. With new engineering colleges coming up virtually everyday, there is tough competition for excellent students and faculty members. In such an environment, it is difficult on the part of any institution to maintain its market share and quality of education. The pressure is also evident from the regular revision of accreditation criteria and curriculum.

One answer for all these difficult situations is application of a quality management system based on the ISO 9000 model. Some of the benefits that can be achieved by implementing a quality management system based on ISO 9001 standard are;

- A systematic way for leading and operating the institution
- Enhanced image of the institution
- Fulfillment of statutory and regulatory requirements
- Processes capable of achieving best results
- Reduction in student failure rate
- Value added products and services to the customer
- Increased customer satisfaction and loyalty
- Increased market share and operational results
- Increased confidence of stakeholders
- Faster response to changing requirements
- Cost saving through effective and efficient use of resources
- Competitive advantage through improved organizational capabilities
- Social benefits from organization's performance
- Motivation of people towards organizational goals
- Continual improvements

DESIGNING AN ISO 9001 COMPLIANT SYSTEM

The design and implementation of quality management system may vary from organization to organization. The ISO 9001 standard does not insist on uniformity of quality management systems or documentation. Most of the ISO 9001:2000 requirements are already present in the accreditation criteria, hence not much effort is required in design and implementation process. However, during the design and implementation process a consultant may be required to facilitate following important activities:

- Management awareness
- Understanding of process management
- General staff awareness programs
- Internal auditor training

In an engineering college a quality system is a set of processes that function harmoniously, using various faculty, staff, material and information resources to achieve set educational goals. The steps and activities required for ISO 9001:2000 standard is better stated according to the structure of the standard itself. The general requirements, as per various clauses of the standard, adapted for engineering colleges are as follows:

Clause 4 (Quality Management System): The ISO 9001 standard insists on the objective evidence for the existence of a quality management system, hence following documents are required:

- **Statements of Quality Policy:** It is the overall intentions and direction of an organization related to quality as formally expressed by top management. The quality policy should be consistent with the overall policy of the organization and provide a framework for the setting of quality objectives.
- **Statement of Quality Objectives:** As defined in ISO 9000:2000, it is something sought, or aimed for, related to quality. Quality objectives are set after establishing the present status. Quality objectives are generally specified function-wise and level-wise in the organization.
- **Quality manual:** Whole quality management system of the organization is described in

the quality manual. It covers scope of the quality management system, documented procedures, interrelation between procedures and any exclusion from the standard. It may be noted that, although exclusions are allowed in the requirements of the standard, only requirements from clause 7 are allowed and they have to be justified in the quality manual.

- Quality procedures required by the standard: It includes procedure for control of documents, procedure for control of records and procedure for internal audit.
- Quality procedures required to ensure effective operation of the processes
- Quality records

Clause 5 (Management Responsibility): This clause requires the top management of the college to prove its commitment to the development, implementation and continual improvement of the quality management system. Necessary activities are:

- Determining customer needs and expectations
- Establishing quality policy
- Identifying current status with regard to quality
- Identification of objectives for improvement
- Establishing, measuring and reporting system for quality objectives
- Process planning (identification of processes, determining sequence and interaction between processes, determining control of processes, availability of resources and information to support processes, process analysis and corrective, preventive and continual improvement actions)
- Defining and communicating responsibility and authority
- Appointing a management representative
- Establishing communication methodology
- Establishing system for management review and conducting management review

Clause 6 (Resource Management): This clause requires that adequate resources in terms of infrastructure, work environment and human resource are provided and maintained to implement quality management system and to enhance customer satisfaction. In context of engineering colleges this may include, classrooms, laboratories, study rooms, libraries, materials, internet connections, etc., human resources may include competence of faculty and staff in performing their tasks, provision of necessary training and professional development, etc. The resource requirement has to be identified, documented and their availability ensured.

Clause 7 (Product Realization): This is the most important and most detailed section of the ISO 9001: 2000 standard. This section deals with all the processes right from the identification of customer needs and expectations, product design and development, resource acquisition and deployment, product and service delivery to the assessment of customer satisfaction.

The most important activity for an engineering college here is the interpretation of these requirements. Once the terms and requirements are translated as applicable to the engineering college, rest of the job can be easily accomplished. The table below lists some of the terms as applicable to an engineering college.

Terms and Requirements	Interpretation
Machine/ Technology	Learning opportunity
Operation/ Tool	Learning opportunity in lectures, tutorials and laboratories
Part Specification	Course and program specification
Product part	Student knowledge accumulated in a course
Realization process	Learning, teaching
Control of Monitoring and Measuring Devices	Establishment of marking and grading schemes to evaluate student performance, student evaluation of courses/ teachers
Customers	Students, parents, employers, industries, professional organizations, accreditation bodies, society
Design Plan	Undergraduate and Graduate programs
Designer	Academic Staff
Process Plan	Individual curriculum
Product	Student knowledge, abilities and competencies
Product Realization	All the processes right from the identification of customer needs and expectations, product design and development, resource acquisition and deployment, product and service delivery to the assessment of customer satisfaction
Purchased Product Quality	Students' academic performance prior to joining the college judged through students marks and/or entrance tests
Purchasing	Enrollment of students
Quality Policy	The overall intentions and direction of the college as expressed by the Head of the College
Raw Material	Student knowledge before entering the college
Raw Material Quality	Students' academic performance prior to joining the college judged through students marks and/or entrance tests
Supplier	High schools, boards and universities from where the students come
Top management	Head of the college, Principal, Dean
Value adding to material	Value adding to students knowledge and abilities
Operator	Teacher, student
Nonconforming product	Student failure to pass a course, Course and Program failure to achieve objectives
Organization	College

Clause 8 (Measurement, Analysis and Improvement): This section requires the college to regularly measure, analyze and improve its performance. Following aspects are included in this process:

- Measuring, analyzing and improving the overall satisfaction of students with course delivery
- Measuring, analyzing and improving student knowledge and abilities
- Measuring, analyzing and improving the expectations of employers and other identified customers
- Measuring, analyzing and improving courses

This section also requires that internal audits be conducted at planned intervals.

IMPLEMENTATION STEPS

As the ISO 9001:2000 standard requires a process approach (Fig. 1), all the activities are process oriented. The basic strategy is; design of processes, documentation of processes, implementation of processes, supporting the processes, monitoring of processes, control of processes and improvement of processes.

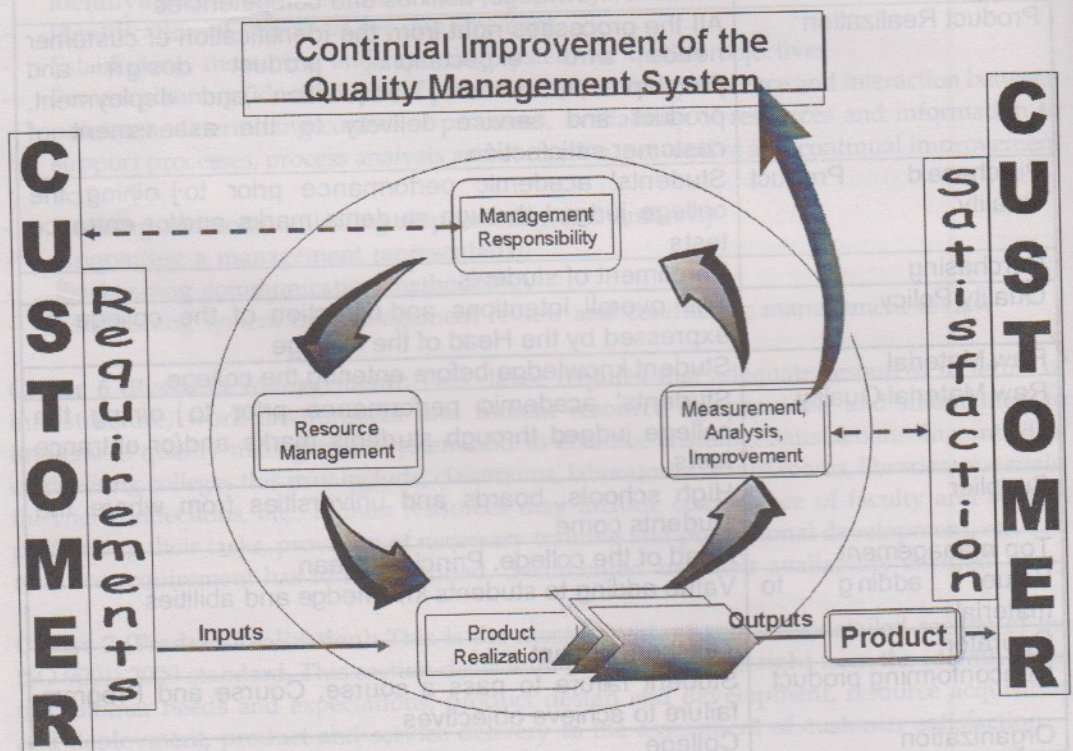


Fig. 1: The Process Approach

Following steps for development, maintenance and improvement of an ISO 9001: 2000 compliant quality management system may be used.

- Top management commitment
- Appointment of Management Representative

- Organizing a coordination committee
- Deciding scope of the quality management system
- Initial gap analysis between existing quality system and standard requirements
- Addressing possible synergies between accreditation and ISO 9001 documentation
- Structuring the quality system from overall programs to individual courses to lectures and labs
- Identifying mutual interactions and synergies of processes
- Organizing quality system documentation (Quality manual, procedures, quality plans, instructions and records)
- Developing objective measures of the quality system performance
- Measuring and monitoring selected indicators
- Internal quality audits
- Corrective and preventive actions to improve performance
- Recording and tracking progress
- Certification

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URBAN TRANSFORMATION OF KATHMANDU'S STREETS:

- Protecting the qualities of urban streets -

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ABSTRACT

Haphazard urban growth, de(recon)struction of traditional building stocks and erection of new structures, often different from the adjacent buildings, changes in land use and building occupancy including growing number of automobiles on the limited urban areas, all resulted from unmanaged rapid urbanisation of Kathmandu have destroyed the physical form, reduced the social activities and increased the vulnerability of accident and pedestrian discomfort on the streets of Kathmandu. These negative consequences can not be addressed through the existing legal and institutional frameworks of the concerned authorities not only because of their limitations in technical, financial and managerial capabilities and lack of coordination among them but also due to poor implementation of the existing ineffective and inadequate legislations. As a result, even recent street improvement works have in fact, discouraged pedestrian movement, degraded unique streetscape and replaced the public spaces by vehicular traffic and above all have encouraged densification of vehicular and pedestrian activities in already congested areas. The overall result is the conversion of all types of streets into 'anti-pedestrian' with reduction of public realm making them more hazardous for both drivers and pedestrians. To change this trend and to protect and enhance qualities of urban streets of Kathmandu, decentralisation of urban activities, enactment of land use and built form regulations including control of population and vehicular densities, on one hand, and formulation of street design standards and guidelines giving first priority on pedestrian movement and enforcement of the traffic regulations, on the other hand, is essential.

STUDY OBJECTIVES AND THEORETICAL FRAMEWORK

Covering about one third of a city area and having multiple functions of both path (access and movement) and place (social setting), the street and its sidewalk as a part of public open space network is the singular urban design element that shapes the built environment, gives neighbourhood character and regulates the people's daily activity. Study of street design goes back to Vitruvius who classified the street scene into three – tragic, comic and satiric (Serlio 1982). Street generally has two generic forms – one carved out from an original block of solid material in which the spatial volume of the street is seen as a positive form against the general background of the surrounding architecture and the other concept sees the city as a parkland, in which the buildings as three dimensional objects stand as isolated sculptural form and streets and other spaces flow around buildings without any shape (Cliff 1991). Many streets of Medieval and Renaissance periods fall under the first category whereas the streets developed under the two city design manifesto of the twentieth century namely new town or garden city movement (buildings were set back and emphasis was on central green area rather than on streets) and the Charter of Athens (streets as places for people were rejected in favour of efficiency, technology and speed) belong to the latter group.

Though the need for designing urban street as main public place rather than for vehicular speed has been advocated by many urbanists (Jacobs 1961, Sitté 1965, Jacobs and Appleyard

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1987, Rapoport, 1987, Lynch 1981), until recently highway engineers have dominated the design and management of streets catering mainly to vehicular traffic with little consideration of streets' role, form and function within urban fabrics. Great street depending on social, cultural and economic factors (Gans 1968) including physical environment such as size and shape, microclimate, amenities and activities (Heng and Chan 2000) should have some designable salient features and requirements (Jacobs 1993). After reviewing numerous literatures on street design and urban transport management, for the context of traditional city like Kathmandu, urban transformation of its street typology can be better analysed within the framework of: (i) physical form and spatial character (ratio of street width to building height, spatial definition and feeling of enclosure, legibility and permeability from the surrounding areas, etc.), (ii) social context (public places for multiple activities, vitality, etc.), and (iii) users' (both pedestrians and drivers) safety and comfort (pedestrian friendly sidewalks, smooth vehicular movement, street amenities, safety from social crimes, etc.).

This paper aims to analyse urban transformation of Kathmandu's streets with fourfold objectives. First, it studies various requirements and criteria of making great streets and based on that it identifies numerous qualities of the streets developed in Malla and Rana periods within the socio-economic context of that time. Second, it analyses the negative consequences of Kathmandu's rapid urbanisation and haphazard urban growth on the traditional streets of the historic core area as well as on the modern streets of both planned and unplanned settlements of the peripheral city areas including implications of the recent street improvement works before identifying various weaknesses of those streets. Third, it examines the existing legal and institutional frameworks of urban development and traffic management authorities to check their capabilities of addressing those shortcomings and finally, it develops some key design policies to protect the qualities of traditional streets as well as to plan future 'good street' in new urban growth area.

REQUIREMENTS FOR GREAT LIVABLE URBAN STREETS

Many requirements and criteria of designing a great livable street are directly related to building good cities: such as accessibility, bringing people together, publicness, livability, safety, comfort, participation, responsibility and so on (Jacobs 1993). Great streets should be easy to find and go, accessible to all and thus easy to record in the mental map. Street forms can be analysed in terms of a number of polar characters such as straight or curved, long or short, wide or narrow, enclosed or open, formal or informal, together with their scale, proportion, contrast or connection to other streets or squares. They are defined vertically (height of the buildings, walls or trees along a street) and horizontally (width of the streets). The Essex Design Guide suggests for the 'great street,' a range of street width to building height ratio within 1:1 to 1:2.5 (Essex County Council 1973) whereas Unwin advocates narrow streets of 6-9M wide with lining buildings of three or four storeys for completeness and enclosure to the pictures in the streets (Unwin 1920). Baron Haussmann used the principle of building height and street width relation – higher building on the wide streets and lower on narrow streets – in reconstructing Paris. New York's first zoning regulations were also based on street width and building height relationship (Marc 1992). It is not only the ratio of street width to building height, but also the quality of buildings especially how they respect one another in terms of height and in the way they look matters a lot. Spacing of buildings along the street and the size of openings of the buildings are other important factors defining the street quality.

Great streets are not only for exchange of services, places to do business, linear physical spaces for public utilities as well as for the movement of people and goods but they also have

symbolic, ceremonial, social and political roles. Moreover, they are public showcases: places to be alone, to be private, to wonder what it was once like, or what it could be like and they should always encourage socialisation and participations of people (Jacobs 1993) so that both 'optional activity' (jogging, sunbathing, watching or standing around enjoying life, etc.) and the 'social activity' (children at play, greetings and conversations, passive contact, etc.) can take place in addition to the 'necessary activity' (going to work, shopping or waiting for a bus, etc.) on the streets (Gehl 1980).

Finally, great streets should be safe, comfortable for all users and responsive to climatic and weather conditions. Though priority should be given to pedestrians for socialisation and public enjoyment in daily life, nonetheless, the drivers should also feel comfortable, safety, pleasing and experience the city.

STREETS DEVELOPED IN MALLA PERIOD

The urban fabric of Malla town¹ comprises of two basic elements - building blocks of closely built three to four story houses clustered around the courtyards and Buddhist Monasteries (Bahal and Bahil) and network of narrow non-axial streets and pedestrian lanes including public squares and courtyards linking these blocks - acting as a figure-ground for each other (Figure 1a).

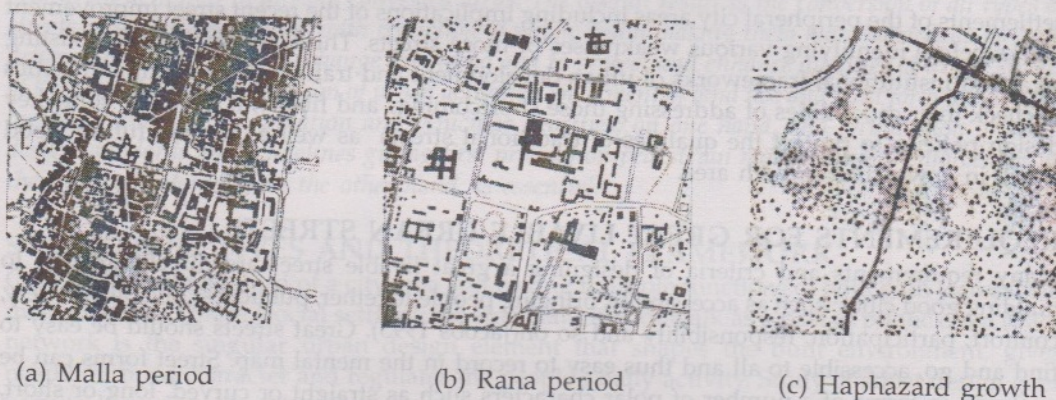
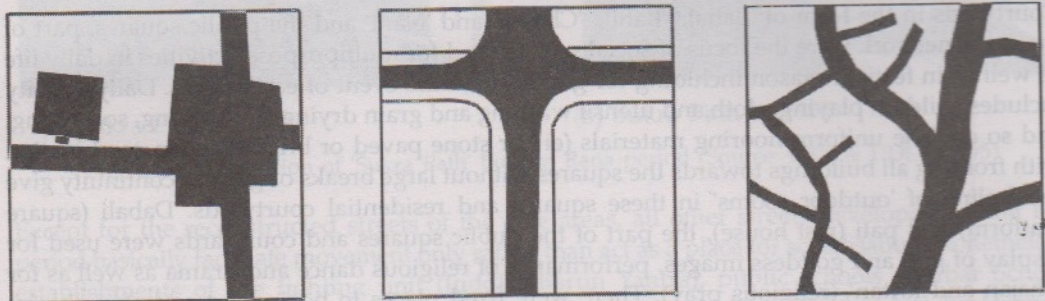


Fig. 1. Urban fabric and street pattern of Kathmandu developed in different political periods

Composition of neighbourhoods and their spatial location, together with housing type, size and style within the town forms a socio-economic hierarchy. People were classified based on their profession (Jaata) and caste group (touchable and socially untouchable) and, accordingly their housing were zoned - high officials, traders and craftsmen (upper cast Newars) surrounding the centrally located palace complex (Hanuman Dhowka) and the lower caste progressively living further away. Socially untouchable community such as 'Pode' and 'Chyame' (sweeper) and 'Kasain' (butcher) was neither allowed to live within the town nor permitted to construct houses of brick and tile, higher than one storey (Burathoki 2039 BS). They lived outside the town wall (Oldfield 1974) and far beyond the wall was the realm of the dead,

¹ Developed across the trade routes of 'Kirtipur' to 'Sankhu' and 'India to Tibet' in the 10th century, Kathmandu, in the following centuries was extended based on 'Mandala principle,' with grid-iron pattern (deviating some 12-15 degree towards the east), dividing the city into three parts - the central part (dathuwa) during 10-12th century, southern part (kotwa) between 12-15th century and the upper part (thatwa) between 15th-17th century.

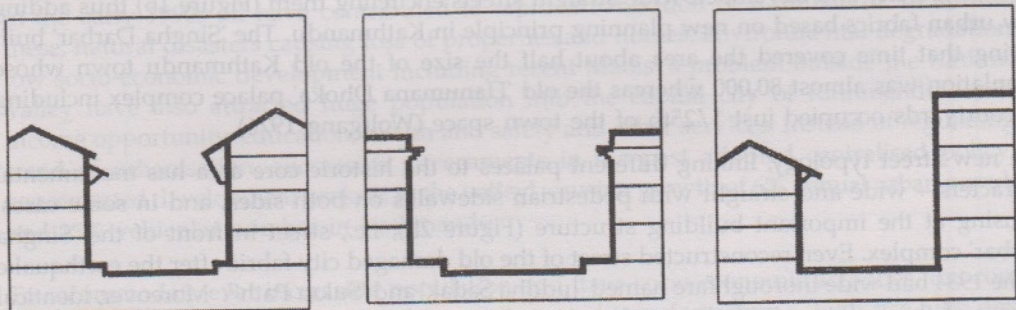
Masan Ghat (Slusser 1982). Street network and its hierarchy was also categorised based on their religious functions into three types², namely: (i) streets around the 'Darbar square' and connecting it to the main town squares (festival procession route), (ii) streets linking different neighbourhoods (for general public), and (iii) streets at the back of the town connected to the major river banks, especially to carry out the dead body (funeral route). The first two types, non-axial streets widening and contracting in different places frequently intersect at different locations within interval of 200-300M to form public squares (Darbar square, market square and neighbourhood square) of varying shape and size (Figure 2a). Courtyards and pedestrian alleys link the individual houses to the non-axial streets.



(a) Malla period (non-axial street-alleys-courtyards-indiv. houses) (b) Rana period (axial street with sidewalks - palaces) (c) Post Rana period (vehicular street-alleys-individual houses)

Fig. 2. Street typology developed in different political periods

Within the boundary wall of the town, streets were generally 4-6M wide with buildings of 3-4 storeys (6.5 – 8.5M) lining continuously on both sides. Hence the street width to building height ratio lies within the range between 1:1 and 1:2, mostly within 1:1.5 thus ensuring the sense of enclosure and human scale (Figure 3a). A sequential specific spatial event is formed which creates a series of picturesque scene. For instance, while walking down from Ason to Maru, visitors feel mystery, surprise, excitement and anticipation at the junctions of 'Janabahal,' 'Indrachowk,' 'Makhan,' 'Hanuman dhoka,' and finally at 'Maru' due to emergence of sudden squares, which are otherwise not visible from the street until one comes closer to such squares.



(a) Malla period (W/H = 1:1.5) (b) Rana period (W/H = 1.5:1) (c) Peripheral haphazard street

Fig. 3. Typical street cross section in each typology

² S. R. Tiwari (1989) in his 'Tiered Temples of Nepal' elaborates the street and urban spaces of the Malla town.

Houses of Malla town were unique – fixed depth of generally 6M with vertically arranged rooms – which facilitated extension on both sides with equal building height. Common lifestyles, use of locally available building material together with similar construction methodology led to a uniformity in architectural styles with little variations only in material quality, workmanship and building façade finishing. Whether the building is three or four storeys high, the façade is often similar and symmetrical. To give continuity in elevation of adjoining houses, the eaves of the skirt-roof of a four storey house continues through at the same level as the roof of an adjoining three storey house (Wolfgang 1976). The overall result is the formation of a singular composition with little variation on building bulk, elevational treatment and roof-lines thereby strengthening the unity in many street scenes.

Courtyards in the form of 'Bahal,' 'Bahil,' 'Chowk' and 'Nani' and the public squares, part of the street network were the focus of social setting used for multipurpose activities in daily life as well as in festival season including for gathering in the event of earthquake. Daily activity includes children playing, cloth and utensil washing and grain drying sun bathing, socialising, and so on. The uniform flooring materials (either stone paved or brick tiled) in combination with fronting all buildings towards the squares without large breaks or gaps in continuity give the feeling of 'outdoor rooms' in these squares and residential courtyards. Dabali (square platform) and pati (rest house), the part of the public squares and courtyards were used for display of god and goddess images, performance of religious dance and drama as well as for 'bhajan and kritan' (religious pray). There were fixed places to begin, end and stop chariot procession during different festivals. This combined with the significant places like 'chhwasa' (a place protected by a demon) and 'lachhi' (private space in front of the house allocated for public use) add cultural meaning to the streets and public squares.

Malla towns, built before the advent of automobiles purposefully have narrow streets, short blocks and many courtyards and street squares with socio cultural amenities. Traditional walkable streets form the backbone of friendly, interactive, safe and secure neighbourhoods. Pedestrians feel safe, comfort and excitement on these streets whereas the large overhang of roofs protects them from the sun and rain.

STREETS DEVELOPED IN RANA PERIOD

Ranas constructed numerous huge palace complexes with extensive gardening based on Neo-classical style of the West, covering the whole street blocks in the higher topography of Kathmandu city and developed wide straight streets encircling them (Figure 1b) thus adding new urban fabrics based on new planning principle in Kathmandu. The 'Singha Darbar' built during that time covered the area about half the size of the old Kathmandu town whose population was almost 80,000 whereas the old 'Hanumana Dhoka' palace complex including its courtyards occupied just 1/25th of the town space (Wolfgang 1976).

The new street typology, linking different palaces to the historic core area has monumental characters – wide and straight with pedestrian sidewalks on both sides, and in some cases, focusing at the important building structure (Figure 2b), i.e., street in front of the 'Singha Darbar' complex. Even reconstructed street of the old damaged city fabric after the earthquake of the 1934 had wide thoroughfare named 'Juddha Sadak' and 'Sukra Path'³. Moreover, identical houses of three storeys with flat roof on both sides of the 'Sukra Path' with uniform white

³ Streets in Malla time were named based on the background of that particular locality (e.g., Jana+Baha = Jana Baha (Buddhist monastery), Bhot+Hiti = Bhotahiti (stone spout), a spout built by a merchant from Banepa, Tamo+Galli (lane/ally) = Tamo Galli, Copper smiths allay, etc.). However, in Rana and recent time, streets and localities were named after people such as Singha Darbar, Juddha Sadak, Ratna Park, Ram Shah Path, Lekh Nath Marga, etc.

plastered walls and continuous cornice and roof lines (Figure 4a) together with the street width (12M approx. including sidewalks) to building height ratio of 1.5:1 ensures a strong sense of being enclosed in an outdoor room with sky as a firm ceiling. New commercial activity induced along this route complementing the existing old trade route along 'Ason' – 'Indra Chowk' has enhanced the pedestrian activities.



(a) Sukra Path in 1940s



(b) Sukra Path in 1992

Fig. 4. Transformation of 'Sukra Path' built in Rana period (Source: GTZ & UDLE, 1995)

Except for the reconstructed streets of the core areas, all other streets developed during this period basically facilitate movement only rather than act as a place for socialisation. Nonetheless, establishments of fire fighting unit (Juddha Barun Yantra), public schools (Darbar School, Juddodaya Public High School, Padmodaya High School, etc.), college (Tri-chandra), Bir Hospital and the Military Hospital, and Electricity Authority around the vicinity of 'Rani Pokhari' and 'Tundikhel' not only demonstrate a new style of composing public structures around urban spaces but are also beginning of the development in the fields of education and health including in public safety against earthquake and fire hazards.

IMPACTS OF RAPID URBANISATION AND HAPHAZARD URBAN GROWTH OF KATHMANDU ON URBAN STREET PATTERNS

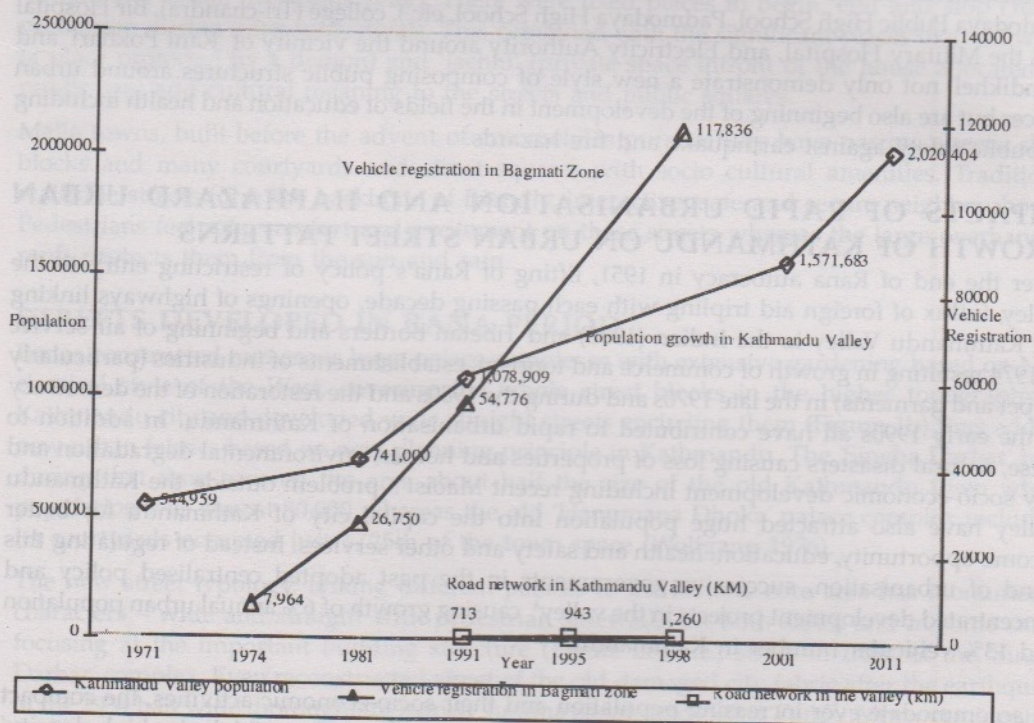
After the end of Rana autocracy in 1951, lifting of Rana's policy of restricting entry to the valley, influx of foreign aid tripling with each passing decade, openings of highways linking the Kathmandu Valley to the Indian (1956) and Tibetan borders and beginning of air service in 1974 resulting in growth of commerce and tourism, establishments of industries (particularly carpet and garments) in the late 1970s and during the 1980s and the restoration of the democracy in the early 1990s all have contributed to rapid urbanisation of Kathmandu. In addition to these, natural disasters causing loss of properties and homes, environmental degradation and low socio-economic development including recent Maoist's problem outside the Kathmandu Valley have also attracted huge population into the capital city of Kathmandu for better income opportunity, education, health and safety and other services. Instead of regulating this trend of urbanisation, successive governments in the past adopted centralised policy and concentrated development projects in the valley⁴ causing growth of 6% annual urban population and 13% vehicular number in Kathmandu.

To accommodate ever increasing population and their socio-economic activities, the compact Medieval town of Kathmandu has been under rapid transformation - 'high rise high density'

⁴ Gurung H. B. in his research 'Dimensions of Development (Kathmandu 1989) found that during 1956 to 1970 about 34% of the development projects were concentrated into Kathmandu Valley which accounted just 0.4% of the national territory and 4.5% of the total population.

(re)development in the historic core area without respecting old fabrics and cultural tradition and 'low rise low density' urban sprawl in the peripheral agricultural land, irrespective of basic amenities and land use regulation and zoning system (Figure 1c). Gradual shift in economic base from agriculture to service and information orientation, change in lifestyles, and availability of new building materials and construction technology have not only resulted in change of the traditional land use composition and destruction of traditional building stocks in the core but have also accelerated the formation of haphazard streets in the peripheral growth areas (Figure 2c and 3c). This in turn has induced new demand of urban streets and public transportation. However, there is no proportionate construction of new urban street compared to the growing rate of automobiles and population (Graph 1). Between the years 1991-1998, only 547Km of new road was added in the valley to serve nearly 1.4 million populations (DOTM 1998). The same data reveals that registrations of two-wheelers used for private purpose dramatically increased from 37,774 to 71,612 compared to slight increase of mini buses and three wheelers (used for public transportation) from 1352 -1527 and from 3844-4262 respectively between 1993-'94 and 1998-'99. One public vehicle covers 200 persons. The overall result is not only destruction of many qualities of traditional streets but also introduction of new set of problems in them as well as streets of the peripheral haphazard settlement areas.

Graph1. Growth of population and vehicle registration including road network construction



(Source: Data taken from National census 1971, 1981 & 1991, KVTDC 2000, JICA 1992, DOR 1990, 1995 & 1998)

NEGATIVE IMPLICATIONS ON THE TRADITIONAL STREETS OF MALLA PERIOD

Cultural sentiment and attachment with the old trade activities in the historic core (comprising of 242 ha) and problems of public transportation, infrastructure provision, security and other difficulties in daily life in the peripheral areas combined with the high land and construction costs have encouraged concentration of people and their business activities within the core area enough to destroy the old city fabrics. Its negative consequences on the traditional streets are numerous.

First, vertical division of traditional building stocks and haphazard renovation and reconstruction of them, often different from the adjacent buildings in terms of scale, material and architectural style including variations in building setback and plinth level has destroyed the earlier street width – building height ratio, the singular composition of continuous street walls, volumetric definition and unity in street scene. Same is true for the streets of Rana period and the peripheral area due to haphazard construction and addition of floors on the existing buildings (Figure 5).

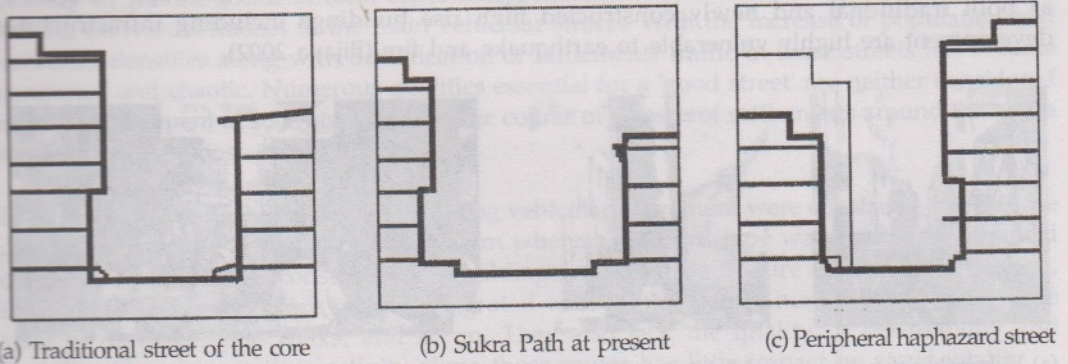


Fig. 5. Destruction of the earlier street form due to haphazard building transformation

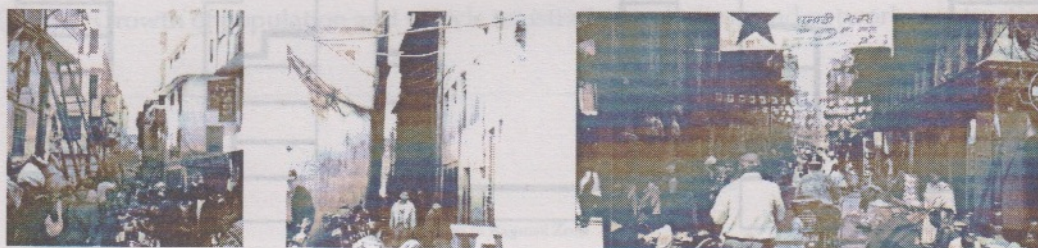
Second, commercialisation of spaces even located inside the courtyards thereby increasing building density and vehicular use has caused the conversion of the public squares, residential courtyards and Buddhist monasteries, an important ingredient of the Malla street system used for multipurpose activities into parking lot, garbage dumping site and stranger's gathering place. One can find the historically significant 'Ason' square and 'Te bahal' being used for car and motorbike parking (Figure 6). This situation has further worsened as many water conduits ceased to supply continuous water and numerous 'patis' (rest houses) attached to 'Viharas' and street squares have been encroached, disappeared or demolished. Traditional land use compatibility - keeping the same professional people in the same locality for work efficiency and social harmony has been disintegrated with the incoming of new inhabitants and changing of ground floor use.



Fig. 6. Street and square of Malla period being converted into vehicular parking (Source: (a) and (b) photos taken by D.M. Chitrakar, Ganesh Photo Lab., Kathmandu, 1998)

Third, walking down on these streets has become hazardous now. Smooth flow of pedestrian and their safety has been challenged in many ways. Absence of well defined continuous sidewalks thereby forcing pedestrians to share the same narrow poorly laid out streets space with vehicular traffic, street hawkers haphazardly occupying the sidewalks and selling different types of goods on the street side, many shop owners occupying the part of the sidewalk/street in front of their shop for displaying goods and people shopping directly from the street all have reduced the pedestrian convenience and efficiency but increased the vulnerability of accident. Old vehicles with low grade petrol and diesels running in the streets of poor condition have further aggravated the traffic situations, besides increasing air and noise pollutions.⁵

Finally, vertical expansion of the core area either by addition of floors on the existing building or construction of new high rise structures often with projection from the second floor onwards coupled with hanging of electric, telephone and television wires from haphazardly placed poles have not only reduced light and ventilation in the streets but have also caused chariot procession difficult in many occasions. Moreover, they have become 'death traps'⁶ (Figure 7) as both traditional and newly constructed high rise buildings including infrastructures development are highly vulnerable to earthquake and fire (Bijaya 2002).



(a) Vulnerable structures (b) Alleys without light (c) Conflict of vehicular and pedestrian traffics

Fig. 7. Numerous activities converting streets and alleys into vulnerable places as 'death trap'

NEGATIVE IMPLICATIONS ON THE STREETS OF RANA PERIOD AND PERIPHERAL HAPHAZARD SETTLEMENT AREAS

In the early 1950s and the 1960s, low density linear ribbon development without adequate infrastructure services took place along the streets connecting the historic core to numerous Rana palaces (DHPP 1969) which further spread out particularly at the intersection areas of the ring road (constructed in the mid 1970s) and the arterial roads such as 'Balaju,' 'Maharajung' and 'Jawalakhel' by the 1970s and 1980s. Such trend has continued unabated till today extending

⁵ Concentration of lead on vehicular streets of Kathmandu is 0.8 mg/cu. m. and Total Suspended Particles (TSP) and Sulfur dioxide were above the WHO guidelines, according to the pre-feasibility study conducted by CEMAT consultants (P) Ltd. in 1999. Again, according to the local daily, The Independent, 2000, the state has to bear a huge amount of economic and social cost: air pollution resulting losses accounts about NRs. 680 million per annum (US\$1=NRs.70.00).

⁶ Recent study of the Kathmandu Valley Earthquake Risk Management Project projected (NSET and Geohazard, 1999) that an earthquake of magnitude of the 1934 can result the collapse of about 60% of houses with 40,000 casualties and 95,000 injuries whereas similar study by Japan International Cooperation Agency (JICA) estimates for the same intensity of quake, the building damage of fifty percent and physically affected of twelve percent of the valley population.

the unregulated development in inland agricultural areas served by pedestrian alleys (Figure 1c) and beyond the city limits into the adjoining Village Development Committees (VDC) including low-lying flood plain areas. Except few pockets of the planned areas, most of urban Kathmandu have been developed through informal process, in which, individual households arrange land on their own initiative, bring access street or path and other services to the site through individual or neighbourhood efforts and build houses entirely by themselves, using their own labour or directly employing construction labour by paying them on a daily basis and finally mobilising all necessary resources by themselves. A study on building permit issued in Kathmandu in 1991 revealed that out of 4150 permits, about 30-35% of houses constructed outside the historic core do not have vehicular access to the building and lack public utilities (MOPE 1999).

Urban streets formed in such areas can be grouped into three categories namely (i) laid out during Rana time but already transformed due to recent rapid urbanisation, (ii) public sector developed paved and non paved vehicular streets, and (iii) narrow spontaneously developed (mainly by private sector or local community) non paved streets including pedestrian alleys linking individual houses to the main vehicular streets. With the increase of population and vehicular densities along with densification of settlements traffic in these streets has become congested and chaotic. Numerous qualities essential for a 'good street' are neither considered in the development of such streets nor in the course of growth of settlements around them due to numerous reasons.

First, the first two types of streets facilitating vehicular movement were constructed before the development of the settlement around them whereas the third type was basically developed on ad hoc basis after the construction of buildings around them (Figure 2c and 3c). As a result, in both cases, the streets are neither integrated with the built form nor have basic amenities such as drainage, side walks, and so on. They also lack the quality of permeability and legibility. Growing retailing activity along those routes has little impact on street vitality

Second, erection of buildings of varying shape and size, bulk and height including different architectural style and building materials, often 'unfit' with the adjacent buildings and the surrounding environment, together with absence of continuous well defined pedestrian paths help to create a chaotic streetscape without any sense of place. Haphazard addition of floors on the existing unifying buildings of 'Sukra path' has destroyed the earlier feeling of enclosure (Figure 4c). In other cases, width to building height ratio does not lie within the desirable limit (Figure 5c) and hence no sense of enclosure and street definition. Unlike in the streets of the historic core, one does not come under surprise, excitement and sequential picturesque scene while walking down on these streets. Different treatments of the 'transition space' between the ground floor shop and the front street (or sidewalk) in each individual buildings (continuous steps, few steps and then wide landing, direct access from the street, etc.) have caused the shoppers and pedestrians inconvenience and slowed vehicular movement. Such streets do not encourage people to be outside for longer and do little with social and commercial encounter and exchange.

Finally, haphazard parking, loading and unloading on any part of the street at any time, different modes and types of vehicles competing for the same narrow streets including encroachment of street space by hawkers and pedestrians thus making motorists inconvenient, on one hand, and encroachment of sidewalks (footpaths), if there exist any,

by shop owners and hawkers and debris from digging of streets for public utility installations and lack of continuous pedestrian network thus reducing pedestrian convenience and safety, on the other hand, have transformed these streets neither pedestrian friendly nor vehicular movement comfort (Figure 8).



(a) Lack of zebra crossing



(b) Lack of sidewalks



(c) Unpaved street

Fig. 8. Pedestrian and vehicular unfriendly streets

The third type of street and narrow pedestrian alleys of haphazard growth areas, developed on ad-hoc basis by piecemeal process has different shape, size and configuration without any clear hierarchy. These streets are often unpaved, lack drainage and sewer lines and sidewalks (Figure 9). In fact, they are the spaces between boundary walls of private houses, left over after building houses on the best location of the site and often act as 'no man's land' or 'waste land,' used for dumping construction material leftover or housing waste.



(a) Inconvenient passage



(b) Unpaved alley



(c) Narrow path

Fig. 9. Narrow pedestrian alleys linking individual house to the vehicular streets

Walking along these narrow streets/alleys is dangerous and inconvenient not only due to lack of pedestrian related amenities but also because of their layout configuration, not accessible to all and difficult to find and to go, often isolated from the people's activities areas. During rainy seasons, these streets are full of mud and water logged making pedestrian movement difficult and in some cases impossible. Neither fire engine nor ambulance can run in such streets thus making large part of settlement areas vulnerable in the event of natural hazard as well as in emergency cases in daily life.

All these factors have contributed towards the increase in road accidents, traffic jams and reduction of road capacity. According to Kathmandu Valley Traffic Police, 67% of all types of accidents in three principal cities of the valley (Kathmandu, Lalitpur and Bhaktapur) involve pedestrians and their casualties are as high as 36% followed by 22% motorcycle riders and 10% cyclists (KVTP 1999). In the same way, vehicular speed has reduced to 20 km/hr. in the

inner core and 40km/hr. in the ring road (JICA 1992). Relating all the vehicles of the valley (assumed only 80% of 117,836 total vehicle registered in Bagmati Zone in 1998-'99 run in the valley) to the total urban road⁷ of 612KM in the valley gives one vehicle just 6.5M of street length (DOTM 1998, DOR 1998).

STREETS OF THE PLANNED URBAN AREAS

Realising the problems of urban sprawl, the government since 1970s has been implementing various land development programs such as site and services (e.g., Kuleswore and Golfutar in 1977), guided land development and land pooling schemes (e.g., Gongabu in 1988, Naya Bazar in 1996, etc.) in different parts of Kathmandu. However, it is the private sector (individual land broker or local real estate company) which has already developed 1038 ha. of land between 1981 and 1991, against the governments planned development of 185 ha. in the same period, that is responding to the market needs by assembling the private lands and making them available in the market for housing of all income groups and other uses.

In both cases, the development is limited to plotting irregular lands into regular one with provision of vehicular access to each property. Plot configuration, street network layout and provision of infrastructure are project specific as planning standards and guidelines do not exist. To maximise profits, private developers often subdivide the land unscientifically with minimum street width with poor junction, insufficient for vehicle turning and without open space and basic public utilities let alone social and emergency amenities. As the construction of individual house is not regulated, there is no question of street wall formation, unity in elevation and control on building height and hence no volumetric definition and sense of place.

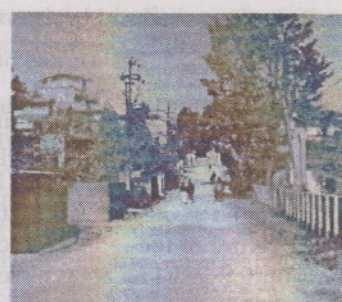
Absence of sidewalks and public open spaces within certain intervals make these streets less useful for socialisation. In addition to these, ineffective linkage to the public transport route, minimum number of shopfronts along the streets and lack of provision to protect walkers from the sun and rain make these streets less pedestrian friendly too (Figure 10). In short, quality of streets of these planned areas is not different from the rest of the streets of the haphazardly growth areas.



(a) Path rather than street



(b) Absence of sidewalk



(c) Isolated street space

Fig. 10. Street of planned Kuleswore area - not different from the streets of other haphazard areas

⁷ Department of Road has categorized the road into four types – National highway, Feeder roads, District roads, and Urban roads (all roads within the urban area or municipality boundary). Again, for the purpose of maintenance, Kathmandu city roads have been further divided into four categories – main access road and VVIP movement, Important trafficked route, less trafficked road, and less important, earth road.

RECENT STREET IMPROVEMENT WORKS

Kathmandu Metropolitan City has been engaging in overhead pedestrian bridge construction, streets widening, street lamp and traffic light installation, and street junction improvement works in different locations of the city under the Municipal Infrastructure Improvement Project (MIIP) since 1994 with the assistance of Asian Development Bank.

In Kathmandu Valley, only 4% of population own vehicle and 10% of population use motorbikes which means majority of population walk for short trips. Hence pedestrian movement including their safety, comfort and convenience must get the first priority as their street level activities increase vitality, safety and enhance commercial sustainability. However, the case of Kathmandu is just opposite, as the recent street improvement works have focused on vehicular movement and drivers' convenience rather than pedestrian comfort. Numerous pedestrian overhead bridges recently constructed at different locations of the one way route around 'Rani Pokhari/Tundikhel' separate the vehicular traffic on one direction but cause more conflicts on other sides of the junction, as one has to take either U-turn or cross the two-ways vehicular street without zebra crossing facility while interchanging public transportation at Ratna Park and Sahid Gate. Senior citizens, children and those carrying luggage or kids find it inconvenient to climb up and down the steps for crossing the narrow streets. Vendors and beggars occupying various parts of the bridges have further aggravated the situation by not only making pedestrian movement difficult but also by increasing chances of thefts, pick pocketing and other social crimes. Finally, such bridge – new architectural element – not only blocks the silhouetting background views but also disturbs the street level pedestrian activities (Figure 11a).



(a) Pedestrian overhead bridge at Jamal (b) Street widening work (c) Incompatible new use

Fig. 11. Recent street improvement works at different locations

Similarly, recent street widening work around 'Tundikhel' and 'Kesharmahal' by reducing sidewalks (and public open spaces) has in fact, encouraged new commercial activities and more vehicular traffic with formation of 'traffic bottlenecks' at different junctions but discouraged pedestrians flow forcing them to use vehicles even for short trips. Lining of trees at the centre of the reduced footpaths and lack of integration of the improved streets with the surrounding existing areas have further reduced the scope of walking (Figure 11b).—Segregation of pedestrians and automobiles with an emphasis on the latter by constructing wider and larger streets is 'anti-pedestrian' and 'anti-urban.' Most of the accidents occur at those locations of low public realm such as 'Ram Shah Path' and 'Singha Darbar' junction, 'Tinkune' junction, 'Maitighar' junction, and 'Koteswore.'

Again, permitting construction of high density commercial complexes such as 'Share Market' building without considering the streets and adjacent buildings in already congested areas like 'Putali Sadak' has not only aggravated the problem of parking and traffic chaos but has also broken down the continuous street walls, similar elevation

treatment (Figure 11c), and smooth pedestrian flow on the sidewalk (due to underground vehicular access from the front street). Finally, fencing 'Tundikhel' and building beautiful parks at traffic islands (e.g., Maitighar junction) and in 'Dharahara - Sundhara' vicinity—clearly demonstrate that the government is not only discouraging people from walking on the streets but also replacing the existing limited urban open spaces for non-public uses.

LEGAL AND INSTITUTIONAL FRAMEWORKS OF THE CONCERNED AUTHORITIES

Design of urban streets and their management should be viewed from a broader perspective of urban transport system within the urban development context. Land use planning, urban design, transportation and traffic management are inseparable to achieve great street design. From the above analysis, it is clear that there exist numerous weaknesses in terms of design and management at present in Kathmandu's streets.

First, the needs of street design in newly planned areas and of conservation of traditional streetscape in the historic core area are yet to be realised. Numerous government institutions responsible for urban development having overlapping mandate and jurisdiction but working with little coordination are yet to prepare comprehensive master plan of Kathmandu Metropolitan City, as the earlier series of plans for systematic development of Kathmandu were never realised. Absence of government's clear policy on land development and infrastructure provision plus lack of the trained manpower has reduced the scope of good street layout even in the planned areas. The local real estate companies neither register their company with the government nor do they get approval of their land development schemes from the Town Development Agency. As a result the unscientific plot division and street layout carried out by private sectors remains unabated. Moreover, Department of Archaeology and other non-government organisations working for heritage conservations are basically concerned with the protection and renovation of individual structures such as old palace, temple, etc. rather than preserving the traditional streetscape and neighbourhood characters.

Second, the existing building bylaws, the only legal vehicle to regulate built form is neither adequate to control those activities such as rapid densification, haphazard destruction and renovation of traditional building stocks, occupancy change in building, etc. responsible for destroying streetscape nor can enhance the street definition and unity in street scene. The Kathmandu Metropolitan City (KMC) is ineffective in even enforcing simple clauses of the bylaws such as building height restriction, through building permit system and monitoring the construction sites. It is believed that more than 90% of building construction in Kathmandu and Lalitpur are non-engineered and unmonitored,⁸ and illegal home construction is as high as 27% (CBS 1997). In many cases, the bylaws are conflicting with the existing other legislations such as 'Ancient Monument Protection Act 1976 (2013 BS)',⁹ and recently enacted 'Local Self-Governance Act 1999' particularly in punishing defaulters.⁹

⁸ According to the local *Kathmandu Post* (Sept 8, 2000) one third of construction in Kathmandu is illegal; and two thirds of 'approved' construction deviates from the approved plans.

⁹ The Ancient Monument Preservation Act 2013¹ empowers the Chief District Officer after getting request from Department of Archaeology, to give order for the destruction of the houses or part of it that are constructed against the prevailing law whereas the newly enacted 'Local Self-Governance Act-1999' gives power to the Mayor to punish defaulter either by imposing fine (upto NRs. 100,000) or by demolishing the building or part of it. Also, the city can not take any action unless it is informed by the affected party.

Third, no institution is responsible for planning, designing and managing the public spaces between the buildings. Different treatments in terms of design and materials in the 'transition spaces' between the streets and the ground floor shop of individual buildings remain unchecked thereby creating chaotic streetscape and rendering inconvenience to street users.

Fourth, Kathmandu Metropolitan City is simply ineffective to control the street vendors and hawkers. No organisation has clear mandate to control the shop owners illegally occupying the public spaces in front of their shops. Adding public facilities such as dust bin, telephone booth, and other amenities to protect pedestrians from the sun and rain is no one's business.

Fifth, streets being public spaces are often used not only for vehicular and pedestrian movements but quite often for laying out of public utilities such as sewer line, water piping and electricity and telephone wiring. Lack of coordination among these public agencies is clearly visible in Kathmandu streets as one can always see digging of the same street by different public agencies.

Finally, recent street improvement works prioritising vehicular movement have disturbed pedestrian movement pattern, damaged the traditional streetscape and encouraged the commercial development and vehicular traffic thereby destroying numerous qualities of urban streets. Despite realization of traffic congestion in Kathmandu streets, no concrete measures towards reduction of vehicle registration and control over haphazard construction of huge shopping and departmental stores or office cum commercial complexes in already congested areas have taken place so far.

There are many weaknesses on traffic management side too. Responsible agencies like Department of Road (DOR), Department of Transport Management (DOTM) and Traffic Police (TP) have similar problems of overlapping and contradicting jurisdiction and mandate besides working with little coordination and cooperation. Constrained by financial and technical capabilities they often blame each other for the chaotic traffic of Kathmandu streets. The Traffic Transport Management Act 1992 empowers DOTM to manage transport and traffic including controls of vehicular emission and condition and road accident (MOLJ 1992) whereas the Local Self Governance Act 1999 strengthens local government's role in planning and development works with little power on urban road sector (MOLJ 1999). But at present, Traffic Police is playing a major role in traffic management under DOR advisory role.

Awareness regarding traffic rules and regulations is minimum among street users. Violations of traffic rules and regulations in many ways by all parties are quite common and frequent in daily life. Pedestrians freely crossing the streets under the overhead bridges, ignoring zebra-crossing and drivers driving recklessly without sticking on a particular lane, overtaking from the wrong side, taking 'U' turn ignoring backside vehicles and stopping even in busy streets all are common scenes of Kathmandu streets. Even in the recently installed traffic light junctions at 'Maitighar' and 'New Baneshwor' areas, both drivers and pedestrians ignore traffic signals on many occasions particularly in the absence of traffic police. To some extent, even traffic police are not fully familiar with the new traffic light system and managing the traffic in rush hour. Collection of NRs. 206,000 from 1,757 traffic violators in one week time in Kathmandu during traffic week reveals the scale of traffic violation (The Rising Nepal 2059 BS).

Enforcement of the existing traffic rules and regulations including license issuing and vehicle checking is very weak. For instance, the Traffic and Transportation Management Act 1992, clause 130 requires motorcycle pillion riders to wear helmets and drivers of four-wheelers to

fasten their safety belt has been enforced from January 2003, after ten years of enactment. Traffic police treatment towards government, private and public vehicles in enforcing rules and regulations is biased.

Finally, occasional celebration of traffic week with different awareness programs has little impact on chaotic traffic of Kathmandu not only due to lack of continuity of such activities by the concerned authorities but also mainly because of attitude of general mass of not cultivating habit of obeying traffic rules and regulations.

CONCLUSIONS AND DESIGN POLICIES FOR PROTECTING TRADITIONAL STREETS AS WELL AS PLANNING FUTURE GOOD STREETS

Based on the framework of physical form, social setting and users' comfort, Kathmandu's streets can be grouped into three distinct typology as a product of socioeconomic reality of Malla, Rana and post Rana periods. In Malla town, streets together with public squares, the focus of socio-cultural activities get the first priority in town layout and act as the positive form against the background of unified buildings whereas streets developed during Rana period have a singular function of facilitating vehicular movement with little consideration of social context, an approach totally opposite from the Malla tradition. Most of the streets constructed in post Rana period are on adhoc basis by piecemeal process without complementing the land use and built form of the settlements. Numerous activities such as haphazard urban growth and land use provision, construction of buildings (mostly non-formal and non engineered) often unfit with the surrounding built environment together with the growing number of automobiles have degraded all types of urban streets of Kathmandu. As the existing legal tools are simply inadequate and ineffective and the concerned authorities have poor capabilities, the recent street improvement works have helped further reduction of pedestrian spaces and hence the scope of socialization, discontinuity of pedestrian movement network and densification of vehicular traffic and commercial development in already congested areas.

To protect and enhance qualities of urban streets of Kathmandu, a twofold strategy is recommended. First, at strategic and city level, decentralization of the activities from urban Kathmandu, enactment of land use and built form regulation and control on population and vehicular densities is essential. Second, at local level, formulation of street design standards and guidelines, development of continuous well defined pedestrian movement network integrating with public spaces and people oriented 'activity nodes' at grade level, and enforcement of traffic regulations giving first priority on pedestrian movement, removal of all forms of illegal occupancy of street spaces and sidewalks including coordination and cooperation between the urban development and traffic management agencies is required. Finally, the following design policies enhance the protection of urban streets of Kathmandu.

Design policies for the streets of historic core area

- Regulate the ground floor land use, building form and architectural style including 'transition space' between the street and the ground floor shops in redevelopment of traditional building stocks;
- Protect and revitalise the traditional public facilities such as 'pati', 'water conduit', 'dabali', etc. and encourage new amenities such as street lamp, telephone booth, signage, etc.
- Give first priority to pedestrian movement over vehicular traffic and demark pedestrian space, zebra crossing, etc. on the streets, and discourage street hawkers, street parking and shop owners from occupying street space; and
- Restrict vehicular movement at certain places during certain time in a day.

Design policies for the streets developed in Rana period

- Preserve the streetscape of 'Sukra Path' by regulating new building construction and ground floor land use;
- Provide trees and plantations to shade pedestrians from the sun and rain (streets in front of 'Singha Darbar' and around the 'Tundikhel');
- Encourage traffic light and zebra crossing wherever possible instead of constructing overhead pedestrian bridges;
- Locate public transport stoppage (and stations) at convenient locations and connect them to main pedestrian movement pattern and pedestrian activity nodes; and
- Discourage haphazard use of signage and other advertising boards.

Design policies for streets of both planned and unplanned peripheral urban areas

- Regulate the new construction particularly at ground level in terms of ground floor use, transition space between the shop and the street to achieve desirable streetscape and pedestrian comfort.
- Balance the street spaces for both pedestrian and vehicular movements, giving first priority to pedestrians;
- Provide pedestrian sidewalks on both sides of streets and make them free from street vendors, shop owners, etc.;
- Connect meaningful public spaces and people oriented activity nodes to the street through continuous convenient pedestrian paths; and
- Provide pedestrian amenities such as street lighting, telephone box, street signage and so on.

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A REVIEW ON SOLID WASTE MANAGEMENT OF KATHMANDU VALLEY

Lakshmi Narayan Choudhari

Abstract

Solid Waste (SW) generation of the five municipalities of Kathmandu Valley is assumed to increase at the rate of 2% annually. All the five municipalities of Kathmandu Valley are facing acute problems of solid waste management (SWM) in terms of collection, transfer and final disposal site. On the contrary, the SW is posing a big threat to the health and hygiene of the people of Kathmandu Valley. This paper deals with the present situation of solid waste management of Kathmandu Valley and action taken by the five municipalities to resolve the problems and make the valley more cleaner, greener, healthier and better place to live in.

In order to solve the current SWM problems, His Majesty's Government of Nepal (HMG/N) in collaboration with the Government of Japan under the technical assistance of Japan International Cooperation Agency (JICA), has launched a joint study program called as "The Study on the Solid Waste Management for the Kathmandu Valley", also named as CKV (Clean Kathmandu Valley) Study. This CKV Study, commenced in January 2004 will, be completed in 18 months.

1. Introduction

"Solid Wastes" is the term used internationally to describe non-liquid waste materials arising from domestic, trade, commercial, industrial, agricultural, mining activities and public services. "Non-liquid" is a relative term because sludges of certain kinds fall within the scope of solid waste management; these arise from industrial sources and from sewage treatment plants.

Solid Waste is "matter in the wrong place". This implies that a matter becomes waste only when a specific owner ceases to have a use for it. Yesterday's newspaper is waste to the man who brought it; but it could be the raw material for a paper mill. Current waste disposal philosophy is to endeavor to treat all wastes as resource materials: some for recycling; some for conversion to fertilizer or as a source of alternate energy; and balance for land reclamation. Solid Wastes comprise countless different materials namely dust, food wastes, packaging, in the form of paper, metals, plastics or glass, discarded clothing and furnishing, garden wastes and hazardous and radioactive wastes.

Domestic wastes have three main characteristics: weight generated, density and constituents, which vary depending upon the level of industrial development. The range of weight generated/person/day usually lies between 250 and 1000g worldwide. The density varies from 100kg/m³ to 600 kg/m³. The volume may range from 1/2 liters to 10 liters/person/day.

There are five municipalities in the Kathmandu Valley namely Kathmandu Metropolitan City (KMC), Lalitpur Sub-Metropolitan City (LSMC), Bhaktapur Municipality, Kirtipur Municipality and Madhyapur Thimi Municipality respectively.

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Table 1 gives the SW generation rate of five municipalities for the year 2004 and projected for the year 2015.



The amount of solid waste generation and collection coverage rates has been estimated by each city.

These amounts cover the municipal waste; i.e. waste generated from households, commercial activities, institutions, non-hazardous industrial wastes, and street sweeping. Construction, agricultural and hazardous industrial and medical wastes are not included.

Table 1: Amount of Solid Waste in the Katmandu Valley

S.N.	Item	KMC	LSMC	Bhaktapur	Kirtipur	MTM
1.	Population	701,499	163,632	75,682	45,253	34,047
2.	Present unit generation rate (kg/cp/d)	0.5	0.5	0.45	0.3	0.3
3.	Present waste amount (t/d)	351	82	34	14	10
4.	Present waste amount collected (t/d)	246(70%)	57(70%)	20(60%)	5(35%)	5(35%)
5.	Waste amount reduced by composting/recycling (t/d)	12	3	1	1	1
6.	Waste amount at dumping sites (t/d)	234	54	19	4	4
7.	Self disposal, open dumping, reuse, recycling (t/d)	105	25	14	9	5

Source: CKV Study Report (2004)

Table 2: Projected Waste Generation by Municipalities in 2015

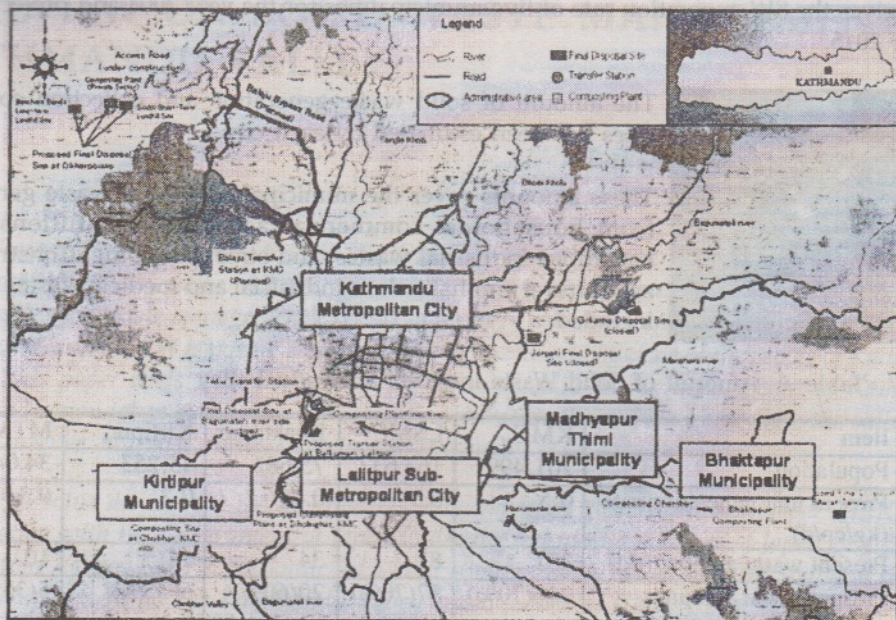
S.N.	Population (2004)	Population (2015)	Waste generated rate (kg/cap/d) (2004)	Waste generated rate (kg/cap/d) (2015)	Daily generated quantity (t/day) (2004)	Daily generated quantity (t/day) (2015)
KMC	701,499	1055,591	0.416	0.519	308.4	547.9
LSMC	163,632	258,751	0.416	0.519	74.5	134.3
BKM	75,682	91,380	0.316	0.394	25.5	46.2
MTM	34,047	83,696	0.266	0.332	14.3	27.8
KRM	45,253	54,400	0.266	0.332	11.6	18.1

Source: CKV Study Report (2004)

2. Field Survey:

The field survey includes (i) waste quantity and quality (ii) time and motion for waste generation (iii) recycling market (iv) interview and questionnaire on SWM practices of households, establishments and NGOs/CBOs.

Five municipalities of Kathmandu Valley



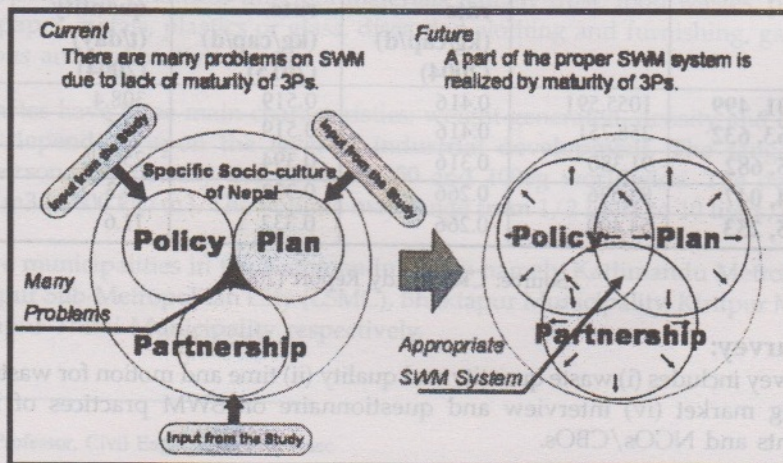
Source: CKV study Report, 2004

3. Objectives of the CKV Study are:

- To formulate Action Plans on solid waste management (SWM) for each of the five cities, and
- To pursue technology transfer regarding SWM study and planning methods for the counterpart personnel.

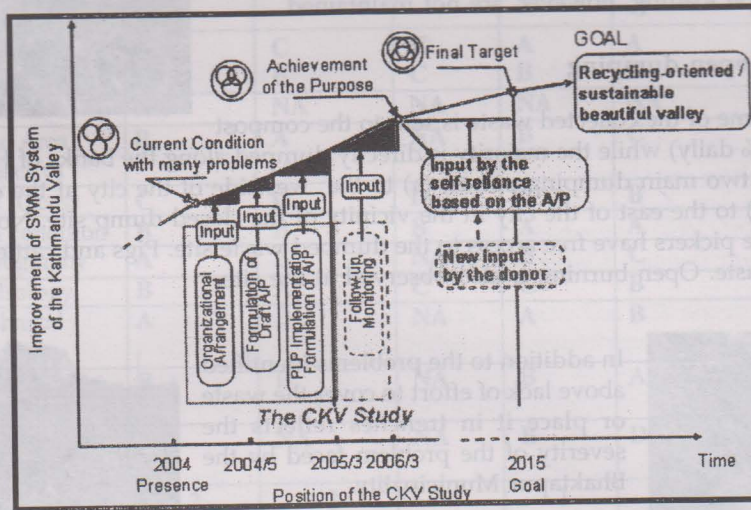
4. Conceptual Model Study

The model is based on Policy, Planning, and Partnership (3Ps) among the stakeholders in the Kathmandu Valley with effective coordination to tackle the current problems of SWM. The appropriate SWM system can be realized by maturity of 3Ps, as shown below.



5. The Duration of the Study

As per the Action Plan, the effective SWM system, including planning capacity and management ability, is expected to be built by the year 2015. The improved SWM system is expected to be implemented by the Nepalese side from 2015 onwards.



6. Current Final Disposal



6.1 KMC and LSMC

At present KMC, LSMC and Kirtipur are disposing their wastes (total 288 ton/day) mainly along the Bagmati river. Furthermore, dumping has proceeded along the eastern Bagmati river bank from Balkhu southwards reaching Sundarighat area. Trenches of height about 3-4 meters and widths of 10-15 meters are excavated and the waste is dropped from the top into the trench. A "footed" compaction roller places the waste. Excavated soil from the trench is placed on top of the disposed waste after the waste has reached the height of the trench. Disinfectants are sprayed to ward off vectors.



The site, although located within LSMC, is operated by KMC. A contractor is hired by KMC to prepare trenches and provide cover soil materials. Both cities have stationed staff at the site to record the incoming vehicle numbers, arrival and departure times. Records on loading, however, are not maintained.



6.2 Bhaktapur open dumping

In Bhaktapur some of the collected waste is sent to the compost plant (about 10% daily) while the majority is directly dumped along the banks of Hanumante river. There are two main dumping points, (a) to the westside of the city at the city's main entrance and (b) to the east of the city in the vicinity of the closed dump site. No cover soil is applied. Waste pickers have free access to the dumped waste site. Pigs and cattles graze on the disposed waste. Open burning is also observed at the site.



In addition to the problems identified above lack of effort to cover the waste or place it in trenches reflects the severity of the problem faced by the Bhaktapur Municipality.



6.3 Kirtipur open dumping



On the opposite side of the Bagmati river, waste collected in Kirtipur is open dumped. Some scavengers are observed at the dumping site. Once or twice a month the municipality takes steps to cover the waste at the site. Some open dumping areas are also observed within the city.

6.4 Thimi open dumping

The collected waste is disposed in open areas and along the rivers flowing in through the Municipality. In Thimi, there is no mechanized collection and transport of the waste. The collected wastes are dumped in the vicinity of the dwelling areas by the inhabitants and the sweepers. There are about 5 to 6 locations where dumping is observed.

7. Findings and conclusions

The study has found that landfill sites were the only possible way for the solid waste management of Katmandu valley. Those sites have been ranked based on their potentialities as follows:

S. N.	Criteria	Phasidol I	Phasidol II	Sisdole	Talkabu	Bhimdhunga	Okharpauwa
1	Haul distance	A	A	C	B	C	D
2	Location restriction						
	(i) Airport	C	C	C	A	A	A
	(ii) Flood plain	B	B	C	B	B	C
	(iii) Faults	NA	NA	NA	NA	NA	D
3	Land Area (capacity)	B	A	NA	B	C	A
4	Site Access	C	C	D	B	B	C
5	Soil condition	B	B	B	A	A	C
6	Topography	A	B	NA	B	C	A
7	Hydrology	B	A	C	C	B	D
8	Technical feasibility	A	B	NA	A	B	D
9	Natural environment	B	B	NA	B	A	D
10	Social environment	NA	NA	NA	B	D	A
	Preliminary Ranking	2	2	6	1	4	5, 4

Because of the technical, environmental, land area and financial aspects related with construction and operation of SWM facilities and constraints of each of the five cities, the Umbrella Concept has been proposed. The facilities may be transfer stations, compost plants and sanitary landfills. At present 190-260 ton/day is dumped in Kathmandu rivers and open spaces. Hence, landfill sites are indispensable for sound SWM of Kathmandu Valley. For this, short-term landfill sites shall commence immediately close to the Bagmati river dump site. The most promising site from the above ranking table is Talkabu, however, due to socio-technical reasons Sisdole site is expected to come in to operate soon from January 2005. The life of Sisdole site is for 2 years only.



Photo: 1 Okharpauwa Landfill Site



Photo:2 Sisdole Landfill Site

The 9.21km asphalt road to Sisdole landfill site has been completed from Tinipale to Aletar and 250 ropanies of land has been acquired for the site. Environmental Impact Assessment for this site has been completed. Leachate coming out from Sisdole site needs to be well treated before it is discharged into Kolpu khola. The 7km from Balaju to Tinipale and 1.62km road from Aletar to Banchare Danda for Okharpauwa site is yet to be constructed. Furthermore,

about 20-25m high ridge needs to be cut and embankment made across the rivulet at Okharpauwa site. The transportation costs for using these two sites are going to be very high. In near future, new alternative sites require to be urgently traced out to solve the sound management of Solid waste of Kathmandu Valley.

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RESTORATION OF AKASH BHAIRAB TEMPLE, KATHMANDU

Ram Sthapit*

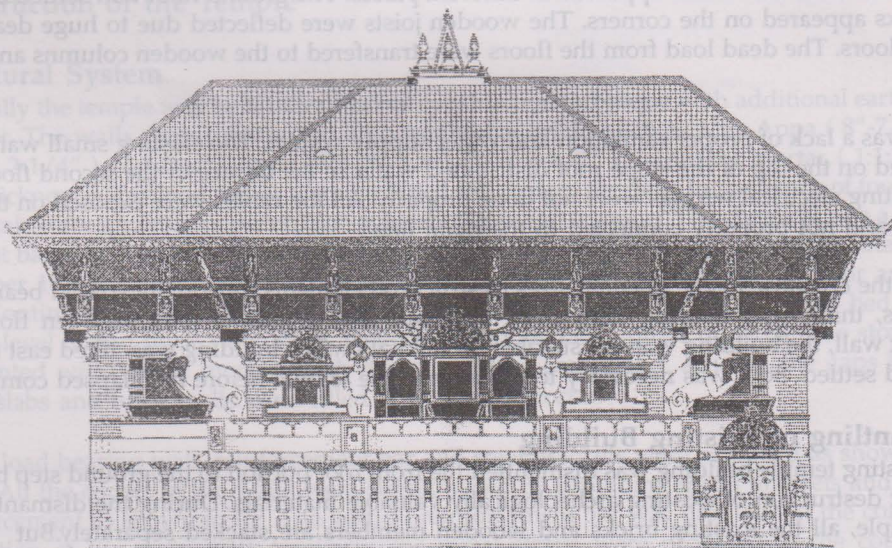
Abstract

The Akash Bahirab temple was located at Indra chowk , Kathmandu. The temple was reconstructed due to wear and tear of material and structural in-stability. The objective of restoration of the temple was to construct the temple in traditional manner and preserve things of archeological value. Also the temple was to be made structurally safe and sound.

Akash Bhairab temple situated at the Indrachowk of Kathmandu was constructed almost 200 years before in pagoda style with slope roof. Due to structural un-stability and deterioration of building materials, it became necessary to reconstruct the temple. Before reconstructing the temple the technical team had inspected the structural condition of temple which is given below:

Existing condition of Temple

It seems that the temple was constructed in stage by stage during different periods. because the existing walls did not have any bond between the adjacent walls. These walls had shear cracks and were almost separated due to the lack of toothing. The walls were constructed with different sizes of bricks The bricks were porous and loose, possessed little compressive strength.



FRONT(EAST) ELEVATION
RESTORATION OF AKASH BHAIRAB TEMPLE

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The existing walls were not in true line and level. Similarly the thickness of existing walls were not similar in the same course. These existing walls are 1'6" to 2'-0" in thickness and constructed in mud mortar. In the ground floor the walls and floors were affected by damp due to lack of DPC. In the foundation, continuous simple strip footing was used. The foundation was deep up to 2m from ground level. Due to high water table and lack of damp proof course bricks were soft and had lost their compressive strength. Also due to lack of proper drainage all the brick walls were damaged and cracks appeared in different places. So it seemed that the existing foundation could not bear the loads coming over it.

The structural wooden members such as decorative columns, girder beams and joists were affected by termites and fungus. In the ground floor the lower portion of columns were already rotten due to the effect of dampness and termites. This led to reduced size of columns. The columns had lost their strength and could not bear the super imposed loads. So temporary supports were provided on the ground floor to support the uppermost floors. Most of the girder beams were badly broken due to unequal massive dead load coming over them. These girder beams were not properly jointed to each other. These girder beams were lapped to each other at mid section of the span. Almost all the structural elements were not of hard wood. They were soft wood such as sala and saj wood. Also sizes and span of wooden columns & joists were not uniform. The loads are not uniformly distributed on the structural elements.

The roof was constructed with wooden rafters and wooden ties which were not of uniform size and were placed in unequal spacing. Wooden chopped logs were provided on the top of the rafters to support thick mud layer (8" to 10") and jhingite tile. Grass was growing in the roof.

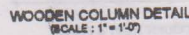
The existing floors were constructed of stone slabs over thick mud. Also the floors were not in line and level and cracks appeared in different places. The ground floor had settled and lots of cracks appeared on the corners. The wooden joists were deflected due to huge dead load of the floors. The dead load from the floors were transferred to the wooden columns and brick walls.

There was a lack of proper sanitation and water supply system. The existing small water tank provided on the top of the slope roof distributed water in the terrace of the second floor. Also the existing electrical wirings were not done properly. All the cables were exposed on the wall surface and not properly connected to the main line.

Due to the eccentric loads, unequal sizes of structural elements, unequally spaced beams and columns, thick mud flooring with stone slab and lack of proper joint between floor and support wall, the building was not suitable for habitation. The building was tilted east to west and had settled. So it was necessary to reconstruct the temple before it collapsed completely.

Dismantling of Existing Building

The existing temple building was dismantled from the roof portion to the ground step by step, without destruction of existing archeologically valuable materials. During the dismantling of the temple, all the existing bricks and wooden members are stacked separately. But deity's throne was not dismantled and temporary support was provided.



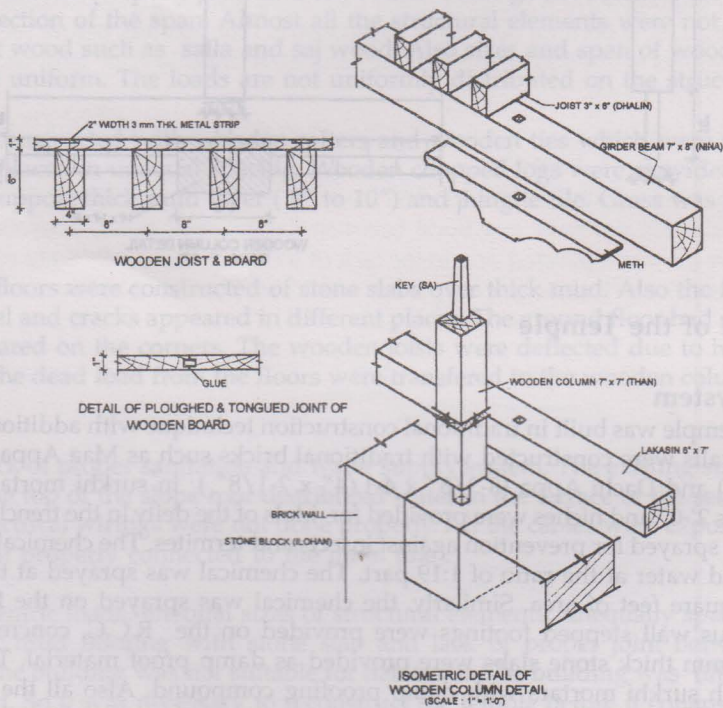
Structural System

In the load bearing wall, reinforcement bar and steel brackets were provided as shown in fig no. 1. All the corner of the walls were strengthened by providing metal brackets and vertical reinforcement as shown in fig. The vertical reinforcement bar was provided at the corner and T-junction of the main wall. Similarly, the metal straps were provided at the corner and junction of the wall at every two feet and connected to the vertical bar. The horizontal metal strips were provided at every two feet height as shown in sketches. To ensure that corner of brick walls would not split out due to horizontal thrust, all the openings in the walls were strengthened by wooden frames and vertical reinforcement. The wooden lintels were provided on the full thickness of wall and anchored to the main wall.

The existing valuable archeological wooden decorative members were reused after anti termite chemical treatment. Similarly, some of the wooden members were reused after strengthening by adding new wooden members as shown in fig no.2. All the wooden members were treated by bathing in chemical soluble bathtub.

Mainly, load bearing walls were designed for self dead load, floor load and imposed load of 400 kg per square metre. All the vertical wooden members were fixed and tied with metal strips and horizontal structural members were securely fixed to the vertical members and anchorage to the load-bearing wall.

Sal wood was used for all structural and decorative wooden members. In the ground floor wooden decorative pillars were fixed on the stone block at plinth level. Ends of wooden pillars were fixed to the hole of stone slab with mortice and tenon joints. Also wooden pillars were tied with steel angles to increase stability.



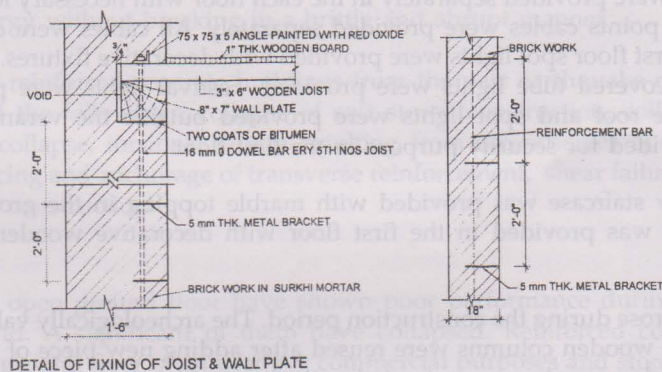
The wooden joist were designed for floor load and imposed load and had a fixed size of 4"x 6". These wooden joists were fixed to the wall plate with wooden keys and metal strips as shown in sketch. The wall plates were anchored to the brick wall with vertical reinforcement bar and metal strip. These joists were tied with steel angles and steel plates and anchored with vertical reinforcement bars as shown in fig no.1.

Wooden Boards were fixed on the wooden joists. The wooden boards were 1" thick and rebate jointed to each other. On the wooden board two coats of bitumen were painted to protect them. All decorative wooden windows and doors were fixed with wooden key in traditional

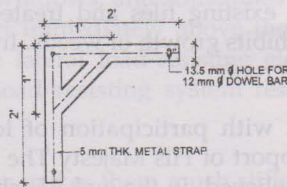
method. The wooden frames contact surface with brick walls were painted with two coats of bitumen. Also wooden windows are fixed with metal angle and strips to the main wall.

All the existing and new wooden members were painted with chemical to protect against termites and insects. The proportion of chemicals were one part of Dust ban TC , ten parts of linseed oil and nine parts of kerosene mixed in the drum. All the existing decorative wooden members were immersed in the bath tub for 48 hours. All the wooden members, which made contact with the masonry walls were painted with two coats of bitumen paint to prevent the moisture contact from the wall.

In the ground floor on top of the flat brick soling 3" thick plain cement concrete was provided for rigid floor. 1000 gauge of polythene sheets were provided as DPC. Telia bricks were provided on the top of the concrete in the ground floor. In the first floor and second floor, R.C.C. slab was provided on the top of the wooden board. In the first floor marble was paved in cement mortar (1:4). In the second floor traditional telia tiles were paved in surkhi The Internal surface of walls were finished with surkhi pointing in ground floor, second floor and attic floor. In the first floor decorative brick shaped brass plates were cladded on the wall. The external surface of walls were cladded with Dachhi Brick and joints are pointed with surkhi mortar (1:1:3).



DETAIL OF FIXING OF JOIST & WALL PLATE



METAL STRAP

Fig 1

On the pitch roof rafters were fixed to the wall plates which were anchored to the main walls. The wooden columns were fixed on the base beam (Lakanshi) and wooden ridge. On top of the rafters 1" thick wooden boards were fixed with screw. Two coats of bitumen paints were provided on the wooden boards. Tar felts were laid on the top of the wooden board for water proofing. The valley and ridges were covered with copper plates for proper drainage of rainwater.

Wooden battens (11/2' x 2"x 2'-0") were fixed diagonally on the wooden board. These wooden battens were painted with hot bitumen. The traditional clay tile (Jhingate) were laid on the mud mortar (yellow clay). The thickness of mud mortar varied from 10" to 20" from top to the edge of the pitch. Last row of the tile was nailed on the wooden battens and raised slightly to prevent from sliding. All the ridge tiles were fixed to a copper wire to prevent them from sliding down the slope.

All the metal members were painted with two coats of anticorrosive paint to prevent corrosion. The silver claddings were provided inside the deity's throne in brick pattern. Similarly wooden columns were clad with silver plate surrounding the deity's throne. All the existing decorative golden windows, toran and door shutters were cleaned and replated with gold. The existing brass big bell was fixed in the first floor with decorative wooden pillar.

Water supply and sanitary systems were provided for daily use along with fire extinguisher. The under ground water tank (10000 lts) was provided on the back side of temple and two numbers of overhead water tanks were provided on the roof. All the water supply and sanitary pipe lines were concealed in the wall. Decorative wash basin was provided in the first floor and taps were provided in the terrace. The taps were provided for fire extinguisher in the first floor.

Electrical systems were provided separately in the each floor with necessary MCBs. The lights points and power points cables were provided separately. All cables were concealed in the brick wall. In the first floor spot lights were provided with decorative fixtures. In the first floor and second floor covered tube lights were provided. Festival lights were provided on the eaves board of the roof and spot lights were provided outside the verandah. The alarm systems were provided for security purpose in the first floor.

The brick masonry staircase was provided with marble topping in the ground floor . The wooden stair case was provided in the first floor with decorative wooden hand rail and balusters.

Several problems arose during the construction period. The archeologically valuable members such as toran and wooden columns were reused after adding new piece of wood as shown in fig 2. These wooden members were treated with chemical before being fixed. Similarly the roof tiles were selected from existing tiles and treated with chemicals. The roof tiles were paved in yellow clay which inhibits growth of weeds. In the valley brass plates were provided to drain out water from slope roof.

The temple was constructed with participation of local ritual peoples. The temple was constructed with financial support of His Majesty The King, Kathmandu Municipality, ward no. 25 and local people who believed in the god Akash Bhairab. Similarly, all the technicians and workers devoted their efforts to achieve great performance during the construction of the temple.

Generally, the Akash Bhairab temple was constructed in traditional method with necessary additional strength for earthquake resistance. The high quality materials were used for construction of the temple. The wooden members were carved as per existing models and as far as possible existing members were reused with treatment. The stone deity's idols were provided in the first floor. So reconstruction of Akash Bhairab temple was completed with great success.

SEISMIC RESPONSE OF REINFORCED CONCRETE FRAME BUILDINGS

*Rekha Shrestha, Ph.D**

Introduction

In recent times, the predominant structural system for the building is reinforced concrete frame with unreinforced masonry infills. A typical reinforced concrete frame building consists of a regular, symmetric floor plan, with square or rectangular columns and connecting beams. The exterior enclosure as well as interior partitioning is of unreinforced brick masonry infill walls. These walls contribute significantly to the lateral stiffness of buildings during an earthquake and, in many instances, control the lateral drift and resist seismic forces elastically. Once the brick infills fail, the lateral strength and stiffness are provided by the frames alone, which then experience significant inelasticity in the critical regions. At this stage, the ability of reinforced concrete columns, beams, and beam-column joints to sustain deformation demands depend on how well the seismic design and detailing requirements are followed both in design and in construction. Good behavior requires that the links deform plastically while dissipating energy without breaking in a brittle and abrupt manner.

The damage to reinforced concrete buildings from the past earthquake can be attributed to one or more of the followings: collapse of soft storey construction, collapse of mid-height storey, overall collapse, torsional failure resulting from eccentricities of stiffness and mass, inadequate spacing and anchorage of transverse reinforcement, shear failure of short columns, poor quality of construction.

Soft Storeys

Buildings with open ground floor have shown poor performance during past earthquakes across the world. A significant of them have collapsed. Reinforced concrete multi-storey buildings with ground floor often used for commercial purposes and store are very common. These floors are enclosed with glass windows, and sometimes with a single masonry infill at the back. Heavy masonry infills start immediately above the commercial floors. The walls make significant contribution to the lateral load-resisting elements on higher floors. This variation in the stiffness of lateral load resisting system results in the formation of "soft storey" on the ground floor.

The presence of walls in upper storeys makes them much stiffer than the open ground storey. Thus, the upper storeys move almost together as a single block, and most of the horizontal displacement of the building occurs in the soft ground storey itself. During the earthquake, the presence of a soft story increases deformation demand very significantly, and puts the burden of energy dissipation on the ground floor storey columns. Many failures and collapses can be attributed to the increased deformation demands caused by loss of stability due to the soft storeys, coupled with lack of deformability of poorly designed columns. Fig.1 illustrates a typical building with a soft storey.

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In most urban areas, the ground floor of most of the buildings acts as soft storey, as one whose lateral stiffness is less than 50% of the storey above or below. Whereas the total seismic base shear as experienced by a building during an earthquake is dependent on its natural period, the seismic force distribution is dependent on the distribution of stiffness and mass along the height. In buildings with soft storeys, the upper storeys being stiff, undergo smaller inter storey drifts.



Fig.1. Collapse of buildings due to soft first storeys (1999 Turkey earthquake)

However, the inter storey drift in the soft storey is large. The strength demands on the columns in the ground storey for this type of buildings is also large, as the shear in the first storey is maximum. For the upper storeys, however, the forces in the columns are effectively reduced. Building with abrupt changes in the storey stiffness have uneven lateral force distribution along the height, which is likely to induce stress concentration. This has adverse effect on the performance of buildings during ground shaking. Such buildings need to be analyzed by the dynamic analysis and designed carefully.

Strong Beams and Weak Columns



Fig.2 Column failure (2001 Bhuj earthquake)

Experience from past earthquakes has shown that columns should be stronger than beams in RC buildings. Most frame structures have strong beams, remaining elastic, and weak columns suffering compression crushing or shear failure. From the past observations, in many cases, relatively deep beams were used with flexible columns, contributing to the strong-beam weak column behavior. This has been caused by failure at the beam/column junction which may have caused one of the floors to fail which in turn created the total collapse. The building shown in fig.2, collapsed due to bad detailing at the joints or even as already mentioned because the beams did not fail plastically and so the columns failed first.

Strong-beam weak-column systems might have resulted in numerous storey collapses following excessive column damage. This is particularly frequent in the first storey of buildings, as the larger openings and higher storey height translate into a lower structural stiffness and strength, leading to "soft-storey" mechanisms.

Lack of Column Confinement and Poor Detailing Practice

Fig.3 shows an example of failure due to few stirrups in a load bearing column. However where the links have failed, most likely due to lack of suitable anchorage, the vertical reinforcement bars have been able to twist and fail. This failure is the cause of inadequate detailing at the design stage. Observation of past earthquakes reveals that most of the structural

damage in frame buildings was due to lack of column confinement and detailing deficiencies making it difficult to maintain the required ductility. This included lack of anchorage of beams and column reinforcement, insufficient splice lengths, use of 90° hooks, poor concrete quality, less than full height masonry infill partitions, and frequent combinations of many of the above. These errors were often compounded by geometric irregularities such as eccentric beam-to-column connections that induced severe torsion. Fig.4 shows beam-column joint failure.

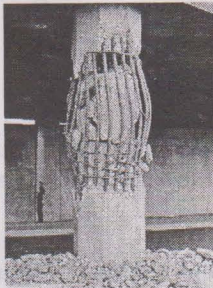


Fig.3 Failure of ties in columns

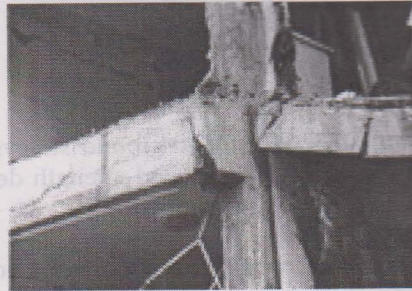


Fig. 4 Beam column joint failure (1999 Turkey earthquake)

Short Column Failure

During past earthquakes, RC frame buildings that had columns of different heights within one storey, suffered more damage in the shorter columns as compared to taller columns in the same storey. Because of the same horizontal displacement of floors in short columns and long columns of the same floor, short columns suffer more. The ratio of Δ/L of short column is more compared to long column, where Δ -displacement is constant for both columns and L varies. Due to this reason shear failure occurs in the form of X-shape cracking in short column. Columns in partially infilled frames having mezzanine floors suffer damage due to short column effect (Fig.5). Such columns should have confining reinforcement throughout their length.

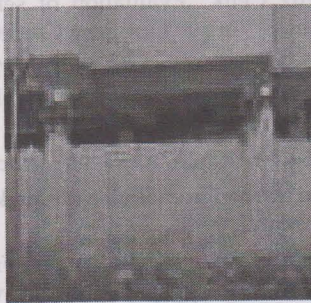


Fig 5. Short column failure

Regularity

Sudden changes in stiffness, strength, or mass in either vertical or horizontal planes of a building can result in distributions of lateral loads and deformations different from those that are anticipated for uniform structures. The effects of such irregularities are such that they are better avoided if possible.

Sudden change in stiffness and strength between the adjacent columns may cause concentration in or around the discontinuity in inelastic deformation. Irregularities in mass, stiffness, and strength can result in significant torsional response.

Pounding Between Adjacent Buildings

Structural pounding occurs during the vibration of adjacent buildings if the gap between the buildings is not sufficient. Pounding may result in irregular response of buildings of different heights: local damage to columns as the floor of one building collides with columns of another, collapse of damaged floors, and in many cases collapse of entire structures. Damage due to pounding can be minimized by drift control through building separation. This phenomenon is in fact a nonlinear contact problem between buildings and should be given necessary emphasis during the design and construction process.

Conclusions

RC frame buildings with open ground storeys are known to perform poorly during strong earthquake shaking. The drift and strength demands in the first columns are very large for buildings with soft ground storey.

The open ground storey is an important functional requirement of almost all the urban multi-storey buildings, and hence can not be eliminated. The underlying principle of any solution to this problem is in (a) increasing the stiffness of the ground storey and (b) providing adequate lateral strength in the ground storey.

Excessive use of soft storeys, lack of column confinement and shear reinforcement, use of strong beam weak columns can be blamed for the majority of failures. The possible damage, loss of lives and properties during an earthquake can be minimized by design and construction of the structural members and their connections to resist seismic forces.

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