Innovative Technologies and Practices for Nepal

Proceedings of 3rd SONEUK Conference

स्मारिका

Society of Nepalese Engineers UK

London

2019

Editorial

Nepal is facing a challenge to accelerate its development after having a new constitution and political stability. Engineering sector contributes significantly to the development of new projects and their successful delivery at both central and local government levels. Currently in the UK, hundreds of Architect and Engineers are working in various areas such as academia, government organisations, consulting firms and construction companies gaining advanced technological experiences and expertise. In its decade-long history, Society of Nepalese Engineers in the UK (SONEUK) regularly organises a number of professional development activities including: training, conference, seminar and talk programs to share and disseminate expertise among the members and to wider public. Many of these interactions are themed at the application and knowledge transfer for the development of Nepal. To further enhance the exchange of technical knowledge to wider public outside of SONEUK family, SONEUK is publishing proceedings of technical papers for the first time.

All the papers in this proceedings authored by SONEUK members are based on their experience gained in Nepal, UK and elsewhere. Wherever possible, an attempt has been made to relate the knowledge gained to make it more applicable in Nepal. The content of the proceedings include various aspects of engineering – architecture, transport, building construction, drainage, information technology, project management and electrical engineering. The papers range from modest to advanced technological applications with current practices in the UK and present some examples of the projects in Nepal. In several areas covered in the proceedings, it is acknowledged that the data scarcity is prevalent in the context of Nepal and the topics covered should be the starting point for a discussion on how expertise available could be utilised in future for research and development through the SONEUK as a platform.

This publication contains a total of 15 papers including a paper on SONEUK History, 6 papers from SONEUK Conference 2018 and 8 short papers. All the papers were peer reviewed using the available resources within the SONEUK to make it to a standard of publication. This being our first attempt to publish, we welcome any feedback and constructive suggestions so that it can be addressed in future proceedings.

We hope that the authors have benefitted through the peer review process to enhance their technical contents and so as to produce good quality papers. We hope that the publication will help towards the technical knowledge transfer and collaboration for the development of Nepal. We also expect that publication of such proceedings will provide a knowledge-base that can be used as a guidance in the relevant technological field to assist in the development need of Nepal.

We, as editorial team, are very honoured to facilitate the publication of the proceedings. At this juncture, the editorial team would like to thank to all authors for their valuable contributions. We hope you enjoy the variety of papers in this first publication as much as we have enjoyed putting them together.

Dr Birendra Shrestha, Transport for London – Coordinator

Dr Ramesh Marasini, Solent University

Mr Krishna Shrestha, Jacobs

Prof Keshav Dahal, University of the West of Scotland

Mr Narad Bhandari, Network Rail

Prof Hom Dhakal, University of Portsmouth

Dr Bidur Ghimire, Wood Group

Ms Pooja Bhagat, Skanska

Content

Print & Design
EPS MEDIA LTD

119 Island Business Centre
18-36 Wellington Street,
Woolwich
London SE18 6PF

t: 02088545332
m: 07429566495
e: sales@epsmedia.uk
w: www.epsmedia.uk

Chairperson's message

As a chairperson of Society of Nepalese Engineers, UK (SONEUK), I am delighted to introduce the first technical publication of SONEUK covering a range of engineering disciplines. I would like to congratulate all authors who contributed to this publication and the SONEUK Seminar and Conference Committee who reviewed and edited the papers. I see this as a culmination of love and passion of all SOEUK members to keep this institution going to reach a new height.

I am fortunate and privileged to have a strong team of this 3rd Executive Committee of SONEUK with other teams of advisors, regional coordinators and sub-committee teams, who have continuously supported to run all extra activities (just to mention a few: MOU signing, proceedings publication) apart from our regular ones: annual get together (Bhela), training & talks, seminar etc.

The entire team has volunteered with their precise time out of work and family business. It is very encouraging to see more young engineers are participating in various activities.

I would like to highlight some of the key achievements since the tenure of 3rd EC, which include:

- Memorandum of Understanding (MOU) with NEA Engineering Company Ltd, Nepal Engineers Association (NEA) and Institute of Engineering (IOE) Dean Office.
- Interaction with the Institution of Civil Engineering (ICE) in the UK.
- Health & Safety collaborative work with Centre for Infrastructure Development Studies (CIDS). Pulchowk Campus, Lalitpur, Nepal.
- 1st Smarika publication (Conference Proceedings) including technical papers.

I would like to thank the distinguished personnel Ambassador of Nepal to UK, Dr. Durga Bahadur Subedi and NEA President Prof. Dr. Tri Ratna Bajracharya for their continuous support to this society.

I also extend gratitude to my entire team and members including their families, who supported to successfully run the society.

In the end, I would like to appeal to all SONEUK members and families to continue to support our society. We will be focusing on capacity building of our organisation, broadening our audiences, launching regular training schemes & talk programmes and organising professional development events, and protecting and advancing interests of SONEUK engineers.

Shailendra Kajee Shrestha
Chairperson
SONEUK

Ambassador's message

EMBASSY OF NEPAL
12A KENSINGTON PALACE GARDENS
LONDON W8 4QU

Message from the Ambassador of Nepal to the United Kingdom,

His Excellency Dr. Durga Bahadur Subedi

I wish to convey warm greetings and best wishes on the auspicious occasion of the eleventh anniversary of the Society of Nepalese Engineers in the United Kingdom. I also wish to appreciate Mr. Shailendra Kajee Shrestha, President of the SONE, UK and his Executive Committee for the excellent preparation for the eleventh anniversary celebration along with the publication of the commemorative journal.

I take this opportunity to congratulate President Mr Shailendra Kajee Shrestha, and his committee for their untiring efforts in leading the SONE, UK for the unity, solidarity and welfare of the Nepalese Engineers in the United Kingdom and for further enhancing Nepal-Britain relations by promoting people to people ties between the two friendly countries. I also wish to pay tribute to the founding President and the past Presidents of the SONE, UK for their wise and able stewardships for developing the SONE, UK as one of the renowned and respected Nepalese organizations in the United Kingdom.

The United Kingdom occupies a very special place in the affection of the Nepalese people. Nepal also holds a very special place in the hearts of the British people. The foundation of relationship between our two countries was not laid overnight. It took two hundred years. Our friendly relations have thus traversed through different eras and withstood the test of time. Celebrating two hundred years together is a momentous milestone for any bilateral relations, in the case of Nepal and United Kingdom something for greater because our two countries hold close, cordial, cooperative and mutually rewarding relations.

The United Kingdom has contributed significantly to improve the social and economic conditions of the Nepalese people. It has continued to provide substantial development cooperation to Nepal. The United Kingdom's valuable assistance has been utilized in critical sectors of development of Nepal such as, agriculture, education, health, human resources development, transport, and telecommunications.

I am very happy to witness that the Nepalese Engineers in the United Kingdom have received recognition, respect and honour from both the government and people of the United Kingdom. The SONE, UK is, I believe, one of the best and well organized Nepalese organizations in the United Kingdom, which consists of more than 200 Nepalese Engineers working in the UK.

I appreciate very much the SONE, UK which is engaged in the professional development and networking of its members on the one hand and is organizing a number of professional development activities including conferences, seminars and talk and interaction programmes on the other.

I highly value and commend the works and activities of the SONE, UK which is covering various aspects of engineering methods, technology and systems and more importantly, its interactions are concentrating on the application and knowledge transfer which would, I believe, be instrumental for the development of Nepal. The SONE, UK is, indeed, working for the good of Nepal and the Nepalese people.

Tel: 020 7229 1594, **Fax:** 020 7792 9861 **Email:** officesecretary@nepembassy.org.uk

Society of Nepalese Engineers UK (SONEUK): A Brief History

1. Introduction

Society of Nepalese Engineers, UK (SONEUK) is a voluntary organisation of Nepalese engineers, engineers of Nepalese origin, living in the United Kingdom. The organisation was formally established in December 2007 in an annual gathering of Nepalese engineers in Central London, UK. As outlined in its constitution, the main objective of SONEUK is to create a dynamic platform for networking among Nepalese Engineers and their families, living in the United Kingdom, for their advancement and welfare.

2. Timeline

The history of SONEUK can be divided into five milestone periods as outlined in Figure 1. Each period is unique to their activities and accomplishments.

Figure 1: Five milestone Periods of SONEUK

2.1 Pre-SONEUK (2004 - 2007)

Looking back to 2004, when many of our friends had started to arrive in the UK under the 2002 Highly Skilled Migrant Programme (HSMP) for qualified and experienced professionals. Apart from the HSMP route, Nepalese engineers had arrived for further education and some already had been settling here since long ago. As many of those newly-arrived friends needed jobs, orientation to the life in the UK, many of us started to make communications among the engineer friends and started networking very quickly. This was because we needed help at least for CV preparation, job search, getting recruiter's details and familiarising with job application process etc. That was an amazing experience that networking between friends had helped many of us to land in jobs they had dreamt of. Vigorous networking had been started among friends, previously known and new friends in various cities in the UK. A couple of informal get togethers that were organised in 2006 and 2007 in London and other cities. Engineers, architects, planners - friends from all sectors including professional, university academicians, engineer students, graduates had advocated for a need of a formal organisation of engineer's society in the UK. In 2006, some friends started to collect names of engineer friends, who had been living in the UK. Some had volunteered to make a central database of engineers with an exciting number of 170 engineers, planner and architects in the list.

Figure 2: Process of the society formation.

Encouraged by the interested friends in contact, enthusiastic friends started communicating with friends and planned a formal get together. The first formal get together was organised in Central London on Saturday the 1st December 2007. About 85 peoples participated in the get together including the 16 family members. The get together not only gave an entertainment but also brought the engineers living in different corners of the United Kingdom closer. There were 69 engineer-participants along with their spouses (11) and children (5) from East Anglia, North of England, Midlands, West of England, South and East England and Wales.

2.2 Ad hoc Committee (2007-2011)

The first meet unanimously decided to form a 13-member Ad hoc Committee for the establishment of Nepalese engineering society in the United Kingdom, this number of members later extended to 18 as given in Figure 3.

Rajesh Pathak, Krishna Kishor Shrestha, Ghanashyam Paudyal,
Naba Raj Adhikari, Bijaya Bajracharya, Raj Pathak
Laxman Ghimire, Bishnu Sharma, Raj Kumar Tripathi
Subhash Adhikary, Kedar Pant, Bandana Shrestha,
Binod Lal Amatya, Bishwo Karmacharya, Keshav Dahal
Rajendra Kharel, Shyam Shrestha, Abdesh Jha

Figure 3: Name of 18 member Ad hoc Committee

The first task of the Ad hoc committee was to propose possible five alternative names of the society and present them to general members for discussion and the final selection.

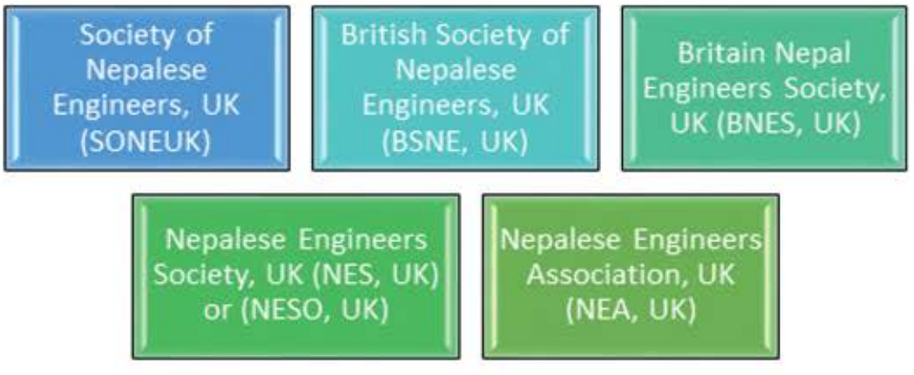

Figure 4: Five Alternative Names of the proposed Society

Email voting was carried out to choose the preferred name of the society. 'Society of Nepalese Engineers, UK (SONEUK)' had received most of the votes among others. Hence, the society was officially named as 'Society of Nepalese Engineers, UK (SONEUK)' in 2009.

2.3 Executive Committees

Following the adoption of the constitution, in the same get together the Ad hoc committee was dissolved, and the first Executive Committee was formed with the resolution unanimously passed by the members present. Successive executive committees were formed, including current 3rd Executive Committee, following SONEUK election procedure, the teams of each committee are given in Table 1 below.

Table 1: Executive Committees

Portfolio	1st Executive Committee	2nd Executive Committee	3rd Executive Committee
Chairperson	Krishna Kishor Shrestha	Ghanashyam Paudyal	Shailendra Kajee Shrestha
Vice Chairperson	Ghanshyam Paudyal	Raj Pathak	Dr Birendra Shrestha
General Secretary	Rajesh Pathak	Shailendra Kajee Shrestha	Umesh Parajuli
Secretary	Laxman Ghimire	Hari Krishna Neupane	Sanyukta Shrestha
Treasurer	Naba Raj Adhikari	Bijaya Bajracharya	Akshaya Chapagain
Member	Abdesh Jha	Anjani Phuyal	Bed Bhattarai
Member	Bandana Shrestha	Dr. Birendra Shrestha	Dr Bidur Ghimire
Member	Bijaya Bajracharya	Bed Bhattarai	Pooja Bhagat
Member	Binod Lal Amatya	Narad Bhandari	Pawan Man Bajracharya
Member	Bishnu Sharma	Saroj Koirala	Rashmi Rana
Member	Bishwo Karmacharya	Umesh Parajuli	Sagyan Kharel
Member	Kedar Pant		
Member	Keshav Dahal		
Member	Raj Kumar Tripathi		
Member	Raj Pathak		
Member	Rajendra Kharel		
Member	Shyam Shrestha		
Member	Subhash Adhikary		

3. SONEUK Constitution

Following the series of discussions, meetings and feedback & comment collections, the Ad hoc committee adopted long awaited the Society's Constitution on 20th August 2011. The constitution is being amended from time to time in line with the requirements of Company registration and Charity commission. The objectives set out in the constitution are as follows:

- To organise social gatherings, which will foster relationship and maintain closeness among its members and families, living in the UK.
- To share experience and exchange knowledge for individual growth and professional advancement among engineers of all ages from graduates to experienced.
- To facilitate for promotion and encouragement of continuous professional interaction and life-learning programmes among members.
- To assist newly arrived engineers and engineering graduates for their orientation and provide guidance in job search.
- To inspire and empower Nepalese Engineers with a sense of pride and achievement through collective actions such as, not limited to, technical conferences, seminars, workshops, interaction and talk programmes.
- To foster collaboration, share experiences and skills between its members and researchers, academicians, & practitioners worldwide.
- To promote continuing professional development, maintain competency and provide support to its members towards gaining recognition of professional membership from the UK professional bodies e.g. ICE, CIHT, RIBA, RICS and others.
- To promote technology transfer for engineering, scientific and technological advancement in Nepal in collaboration with other institutions in Nepal and abroad.
- To maintain relationship with other Nepalese charity organisations and provide technical support, especially on engineering aspects.
- To expand membership to recent engineering graduates and engineering academics of Nepalese origin living in the UK, and maintain the members' database.
- To recognise members and their families for their outstanding contributions to the welfare of the society.

Following the adoption of constitution and structuring of the organisation, the society has been registered under the company house as "company by guarantee". Recently in 2018, the society has been registered under the UK Charity Commission.

4. SONEUK Activities

4.1 Annual get together (Family Bhela)

The annual social events, as shown in Figure 5, were organised for the members and their families since the establishment of the society. Presentation of annual activities, membership renewal endeavours and discussion about future activities were organised while spending time in entertainment with families during these events. The yearly social events shown in Figure 5 include annual general meetings (AGM) and elections as well.

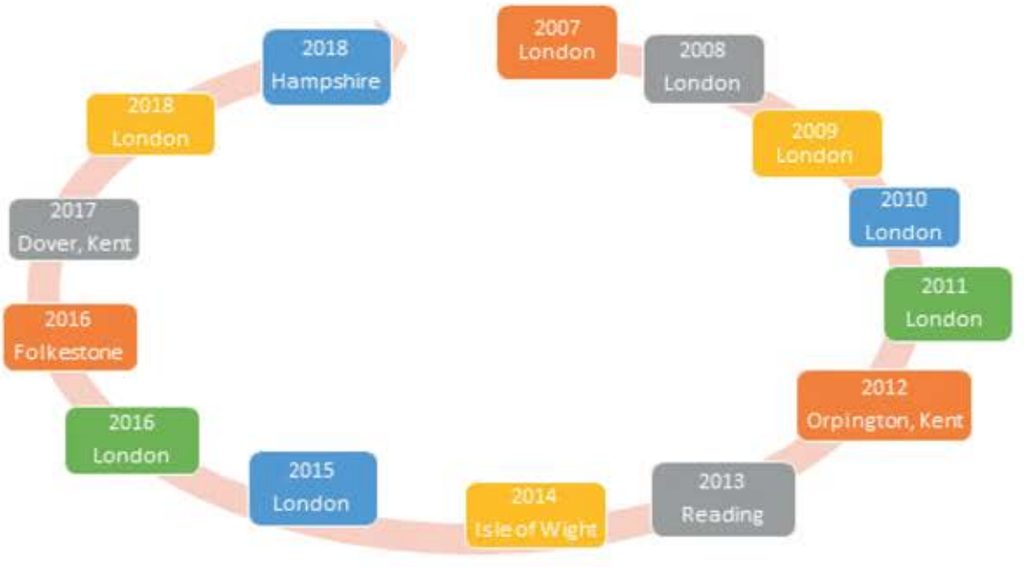

Figure 5: Social Events organised by SONEUK (by year and location)

4.2 Charitable Activities

The charitable activities carried out by SONEUK are as follows:
2008 Support to Flood victims: 1st charitable activity of SONEUK, fund collected and handed over equivalent to One lakh Rupees (NRs. 1,00,000) to Embassy of Nepal.

- 2015 Support to Earthquake victims: massive fund-raising campaign raised £9,471.28. Out of this amount, One lakh Nepalese Rupees was donated to NEA and the rest handed over to Prime Minister Relief Fund through Embassy of Nepal

- 2016 Support to NRNA UK: Technical support for 'Design of Nepal House (NRNA UK) was provided as a Technical Partner of NRNA UK

- 2017 Support to NRNA UK: Technical support for Design of Sisire School Building and Design of Tharpu College Library Building

4.3 Trainings

- 2009 Oct & Nov: Project Management (Primavera) (resource person Kedar Pant)

- 2010 Apr: Project Management (Primavera) (resource person Kedar Pant)

- 2010 May & Jun: AutoCAD training (resource person Shashi Manandhar)

- 2017 Nov: Mission Possible - A Project Management programme (resource person Bijaya Bajaracharya)

- 2019 Feb: GIS Training: 'GIS for All' (resource person Dr. Bidur Ghimire)

4.4 Seminars and Talk Programmes

- 2014 Sept: Interaction programme with Lal Krishna KC, an entrepreneur, on 'Prospects of Investment in Infrastructure Development Projects of Nepal', London
- 2016 Nov: Interaction with Dr Dinesh Devkota, PhD, Former VC, NPC on 'Development Challenges and the Way Forward', Blackheath, London
- 2017 Sept: Interaction with Dr Amod Mani Dixit, NSET, UCL, London
- 2017 Sept: Interaction with NEA President and Gen. Secretary, Blackheath, London
- 2018 May: SONEUK Regional Meeting, Glasgow, Scotland
- 2018 Jul: Talk programme with Badan Lal Nyachhyon on Nepali Heritage, and with Narayan Gurung on Post earthquake Scenario, Blackheath London
- 2018 Oct: Interaction programme with Hitendra Dev Shakya, managing director of NEA Engineering Company, Plumstead, London
- 2018 Nov: Talk programme by ICE MDO Mrs Kate Harrison & Er Laxman Ghimire on 'ICE Professional Development Review', Ealing, London
- 2018 Nov: MOU signing with NEA Engineering Company in Nepal
- 2018 Dec: MOU with Institute of Engineering (IOE), Tribhuvan University (TU), Nepal
- 2019 Feb: MOU signing with Nepal Engineers' Association (NEA), Nepal

4.5 Conferences

- 2015 Nov: Conference on 'Post Earthquake Reconstruction: Challenges and Opportunities', Northolt, London
- 2017 Feb: Conference on 'Infrastructure Development in Nepal ', Greenford, London
- 2018 Apr: Conference on 'Innovative Technologies and Practices' for the Development of Nepal, Wembley, London
- 2019 Apr: Conference on 'Engineering for Sustainable Development of Nepal: Opportunities and Challenges' this is already underway), London

5. Conclusions

The journey of Nepalese engineers in the United Kingdom for almost 13 years has demonstrated that a lot of efforts have been made by its members to bring the organisation to this stage. The Society has now established as a charitable organisation and has been organising social, charitable and technical enhancement events on a regular basis. The Society is dynamic and advancing to achieve its objectives. However, bringing members from diverse engineering disciplines and locations together under one umbrella is challenging.

In the next phase, the Society is swiftly moving towards expanding its activities in various areas including: provision of support for professional development, collaboration with established professional institutions e.g. ICE, IEE, RICS, RIBA etc. Furthermore, collaboration with similar organisations from Nepalese diaspora in other countries outside the UK and transfer of knowledge and technology to Nepal will also be an area of focus of the society in coming days. The recently signed Memorandum of Understandings (MOU) with NEA Engineering Company, Institute of Engineering (IOE) and Nepal Engineers' Association (NEA) are examples of such efforts to take the society to a new height.

Collaborative working: An experience from Crossrail project

Rajesh Pathak

Project Manager, Crossrail Southeast Section Project

rpathak127@yahoo.co.uk

Abstract

Southeast section of Crossrail project known as Crossrail Kent is one of the most successful project in the United Kingdom. Despite the challenges of difficult ground condition, integrating multidisciplinary design, complex construction interface, involvement of large number of stakeholders, constraint site condition and requirement to keep the existing railway operational for public use while carrying construction works, the project achieved all four Key Dates as scheduled and completed on budget. The project was finalist team under "Great Team Work" category for Network Rail infrastructure project award 2017. The project is also short listed under two categories of "collaborative working" and "effective construction planning" for UK Rail Industry Award (UKRIA) 2018. This paper discusses the project scope in brief; project interface and stakeholder management, major challenges faced by the project and collaborative working for successful delivery of project.

1. Introduction

Crossrail Southeast Section project is part of £15 billion railway being built in London. The project is budgeted circa £250 million and it connects Crossrail between Abbey Wood and Woolwich at South East London. The project scope involves moving the existing North Kent railway to provide space to build two new Crossrail lines and overhead line electrification, building a new station at Abbey Wood as terminus station with future passenger growth capacity and providing facility for wider transport interchange, urban and community integration so that it can act as a catalyst for local regeneration.

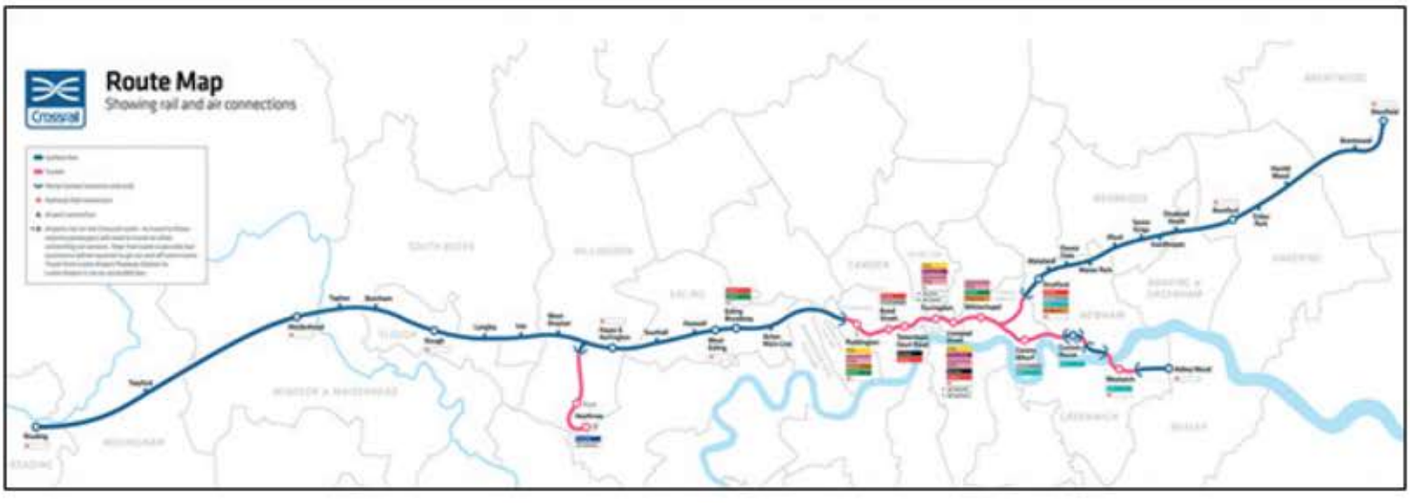

Figure 1: Crossrail Route Map

The Crossrail route will pass through 40 stations and run more than 100km from Reading and Heathrow in the west, through new twin-bore 21 km tunnels below central London to Shenfield and Abbey Wood in the east. Crossrail will increase London rail capacity by 10%. Network Rail is delivering on network works for Crossrail project. Network Rail hired Bechtel Corporation as delivery partner to manage the delivery of these large and complex infrastructure projects. Engineering form WSP (Parsons Brinckerhoff) carried out the detail design with the support from architect Fereday Pollard, structural designer TonyG and other number of designers. Balfour Beatty was hired as the principal contractor for the project who engaged with more than 200 sub-contractors and supply chain to deliver the project. Construction contract awarded late 2013 and mobilised on site from early 2014.

2.Project interface and stakeholder management

Project has many stakeholders as shown on Figure 2. The success of the project was very much dependent on getting necessary support and collaboration from the stakeholders. In order to manage stakeholders effectively it was important to understand their needs, interests and power of each of them. This means ascertaining their goals, reviewing past reactions, considering expected behaviour and probable reaction, assessing the likely impact of project activities on them, and gauging the extent of buy-in and level of support offered.

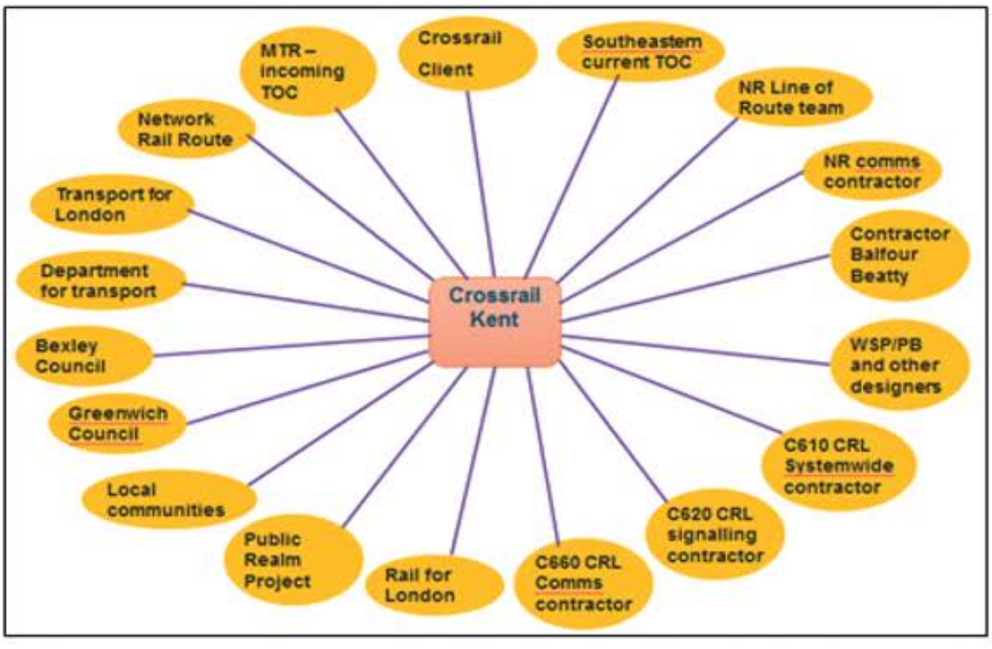

Figure 2: Stakeholder map of Crossrail Kent project.

Johnson et al. (2008) developed power versus interest matrix which indicates the type of strategy the organisation needs to adopt in relation to each stakeholder group. Figure 3 shows strategies that could be used to engage the key stakeholders in the project based on power and level of their interest

Fig 3: External Stakeholders analysis: Power versus interest (Adapted from Johnson et al., 2008)

Dynamics of stakeholders' management have been constantly changing. The matrix provided in Figure 3 only represents a snapshot of a time or stage of the project. The key players and keep satisfied members constantly changing with the priorities and context of work situation e.g. working to install overhead line on the handed over track required access from other Crossrail contractors while working around existing station required agreement with train operating company. To achieve the successful collaboration, huge efforts should be put into stakeholder management. In this project, the client team, contractor and designers were motivated to effectively engage with the stakeholders and interfacing parties at the earliest opportunities.

3. Project issues and challenges

3.1 Design integration

There were more than 30 designers working for the project in design of various elements of this large and multidisciplinary project. The elements included from the track design to signalling, electrical & power, overhead line electrification, drainage to station building, mechanical, electrical and public health systems, station communications systems, public announcements, CCTV, lifts and escalators, highways, fencing and landscaping designs. Coordinating and integrating these designs to meet a very tight accelerated programme remains challenging throughout the project. Figure 4 shows Footbridge crossing North Kent and Crossrail lines and tunnel portal approach.

Figure 4: Footbridge crossing North Kent and Crossrail lines and tunnel portal approach

3.2 Managing construction interfaces

There were more than 200 subcontractors and supply chain working to complete the project during the four years of project construction. Understanding each of the contractors requirement, ensuring safe system of works have been applied, de-conflicting their works and managing interfaces between the project subcontractors and also with external Crossrail and local authority contractors were relentless task for the years. This made even difficult due to constraint site, restricted access due to operational railway and difficult ground condition.

3.3 Working alongside the operational railway

During the feasibility study one of the options proposed were to shut the railway between Plumstead and Belvedere for a period of at least six months to allow critical railway and station works interfacing with the operational railway to progress. Shutting down the railway for six months would have severe consequences on the local peoples' daily life local businesses. The methodology was developed to carry out these critical works during the major possessions like Christmas, Easter, bank holidays, weekends and night shifts and keep the railways running during the normal working hours.

3.4 Poor ground condition

The detail geo-technical investigation concluded that building the new track on a virgin ground of poor ground condition and flood prone area on the traditional style could create un sustained settlement on its life time. Therefore it was designed to build the new track on up to 900mm thick reinforced concrete slab supported by up to 20 meters deep piling. The requirement of ballast slab across the route created additional pressures on the tight construction programme.

3.5 Community issues

The project needed to demolish existing station and number of houses, building more than 10km of new railway, four bridges, new station and associated works in the middle of densely populated settlements. Due to the requirements to minimise the disruption to the operational railway, the work was carried out during the festive seasons, weekends and night shifts. There were dust, noise and disturbances to the local residents despite project effort to minimise them. Project supported number of local residents on installing triple glazing windows and deployed dust mitigation measures throughout the project. Project has proactively and continuously engaged with the local residents through letter drops, door knockings, drop-in sessions and community liaison panel meetings on informing work plan and addressing the local issues as far as practical.

4. Collaborative working

Construction industry lacks the 'strength' of relationships necessary to create networks of organisations that trust and have shared values (Fulford and Standing, 2014). Traditional procurement process reinforces socio-cognitive barriers that hinder team efficiency. It also illustrates how new procurement models can transfer the dynamics of relationships between the client and the members of the supply chain and have a positive impact on team performance.

The project was awarded under lump sum contract putting most of the risk to the contractor. Despite all parties interested to work collaboratively the contract type did not promote problem sharing and working together to resolve the issues. It rather promoted protecting their own position and putting blames on others. Halfway through the project, it suffered by more than six months delay on the programme and potential cost overruns of millions of pound causing serious relationship breakdown between client, contractor and key stakeholders. The delay would not only impact the southeast section project but also the fit-out of Crossrail tunnels as this was the route for all plants and materials to the tunnel. The project took a bold decision to scrap the lump sum contract, re-valued the remaining works and entered in to cost reimbursable contract for the reminder of the work scope. The later arrangement promoted transparency, knowledge sharing and collaborative working among client, contractor and supply chain.

British standard BS11000 provides a framework for collaborative working. The standard incorporates eight stage lifecycle models of operational awareness, knowledge sharing, internal assessment, partner selection, working together, value creation, staying together and exit strategy with the objective of creating a robust platform to maximise benefits of collaborative working by supporting the culture and behaviours necessary to optimise integration. The collaborative working however does not come without drawbacks. It requires active involvement on day to day activities and in decision making process both from client and contractor team. Client's role is very important to make the process successful by committing and engaging with the contractors and their supply chain on this process.

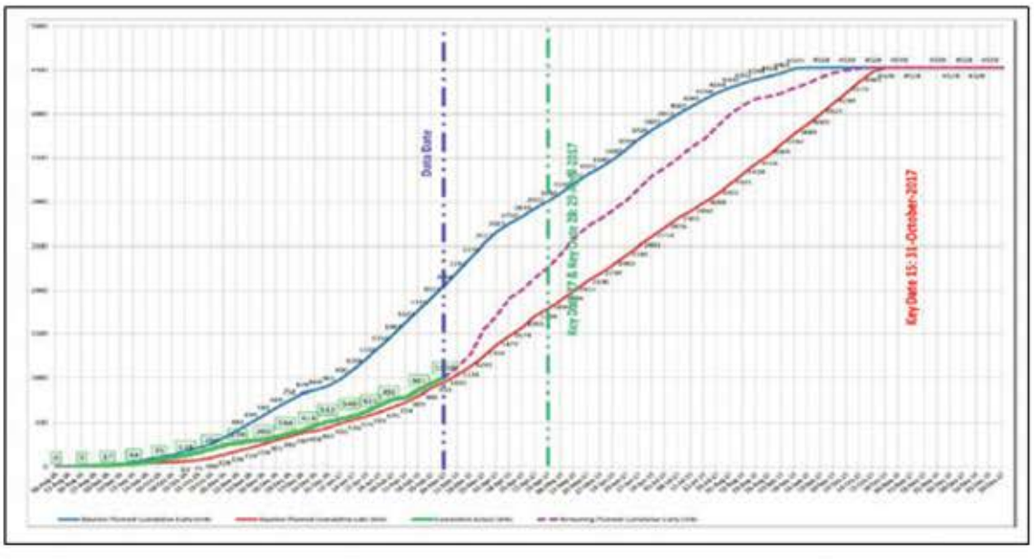

Figure 5: Activity count envelope showing early start, late finish and project performance

A revised baseline programme was prepared (Figure 5) with weekend and night shift working to recover the delayed programme. The programme was monitored on daily basis under short-term-control procedure adopted by the project. Additional resources and corrective measures were deployed where necessary to mitigate potential issues on design, approvals, procurement and construction/installation programme. Collaborative approach worked well in the project bringing all parties together in delivering key project milestones on time. Table 1 shows actual against contractual key dates.

Table 1: Contractual Key Dates, delay forecast and actual completion dates

Key Date	Description	Contractual Date	Delay forecast	Actual completion	Delay mitigated
KD26	Infrastructure complete to enable Crossrail systems fit-out of Central Tunnel Section	10 May 15	-	10 May 15	-
KD27	Completion and handover of Signalling Equipment at Abbey Wood Station	30 April 17	-	30 April 17	-
KD28	Track & Civil infrastructure complete for signalling systems overlay installation	30 April 17	07 Nov 17	30 April 17	191
KD15	Infrastructures complete to support dynamic testing	31 Oct 17	27 Mar 18	22 Oct 17	156

5. Conclusions

Delivery of large and complex project is challenging. A recent report (McKinsey, 2017) states that large capital projects that are completed on schedule and within budget are the exception, not the rule. The report reviewed a dataset of more than 500 global projects above US$1billion in resource industry and infrastructure, and found that only 5% of projects were completed within their original budget and schedule. In the completed projects, the average cost overrun was 37% and average schedule overrun was 53% (McKinsey, 2017).

The project has achieved lost time injury free 1,200 days and project Accident Frequency Ratio of 0.09. That means there were two Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) in four years of construction works. Despite having zero accident aspiration this is a lot better result than the industry average. All Key Dates set 7 years ago were achieved on timely manner. The station was opened for public use on time and infrastructure were completed to receive new Elizabeth line train for testing purpose ahead of required date. The project also remains on budget. Reflecting on the journey of getting the project back on track and achieving all project requirements on timely manner, it can be concluded that the collaboration between the parties and effective engagement with the stakeholders are the fundamental reasons for the success of the project.

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Tunnelling and the Underground Metro Rail in Kathmandu Soil

Dr Binod L. Amatya

Consulting Civil Engineer, Arcadis, London

blamatya@hotmail.com

1. Background

Kathmandu is an historic city with heritage areas everywhere. Modern Kathmandu has however evolved haphazardly without adequate urban infrastructure and planning. As a result public spaces are limited and narrow roads are barely coping with the traffic demand. The city is facing transport chaos and environmental disorder, especially air pollution. Kathmandu needs a 21st century rail infrastructure to resolve these problems. A new mode of transport, the underground metro railway system, is necessary to maintain its historic value at the same time offering efficient transport system in the densely populated area. This would provide a mass transit capability in the city, which could bring economic prosperity, improved quality of life and sustainable development in the region.

2. Ground condition of Kathmandu

The Kathmandu Valley was a lake thousands of years ago but the plate tectonics activity of the Himalayan region caused the lake water to drain out gradually so that the place became habitable. Studies show that in general fluvio-deltaic facies is predominant in northern part of the Valley while lacustrine facies is in the majority in the southern part. This means that the northern area of the Valley is sand-dominated while southern area is clay-dominated. The bedrock in the central area is anticipated to be as deep as 500m (Yoshida and Igarashi 1984). A schematic geological section of the valley is shown in Figure 1. In general, the top ten to fifteen metres of the subsurface of the central area is fluvial deposit and is a complex sequence of mostly loose sand and soft clay, exhibiting weak strata. Such strata overlays black silty clay deposit known as Kalimati. Typical soil profiles of the central area of the Kathmandu valley are shown in Figure 2.

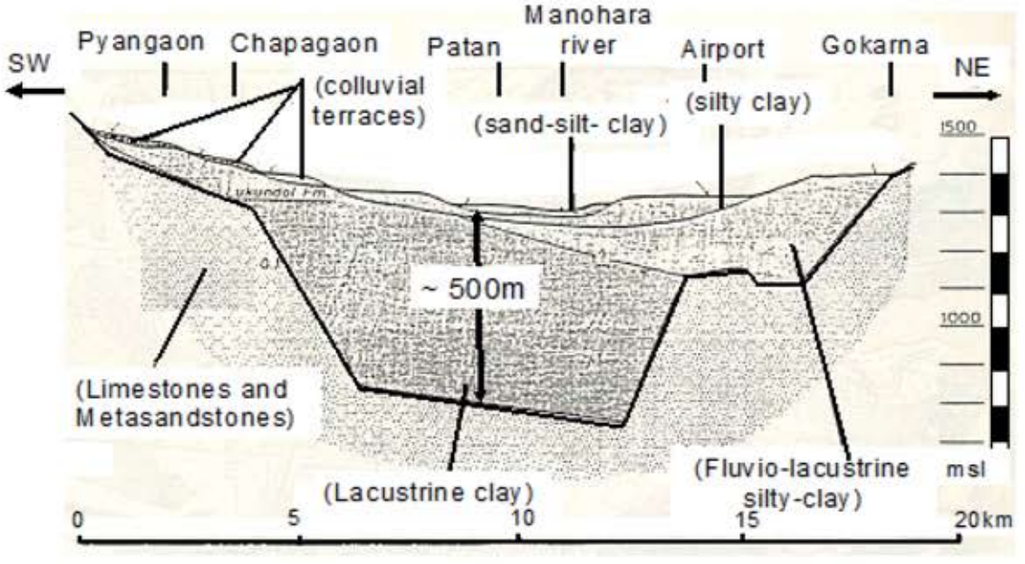

Figure 1: Schematic geologic section of Kathmandu Valley (Yoshida and Igarashi, 1984)

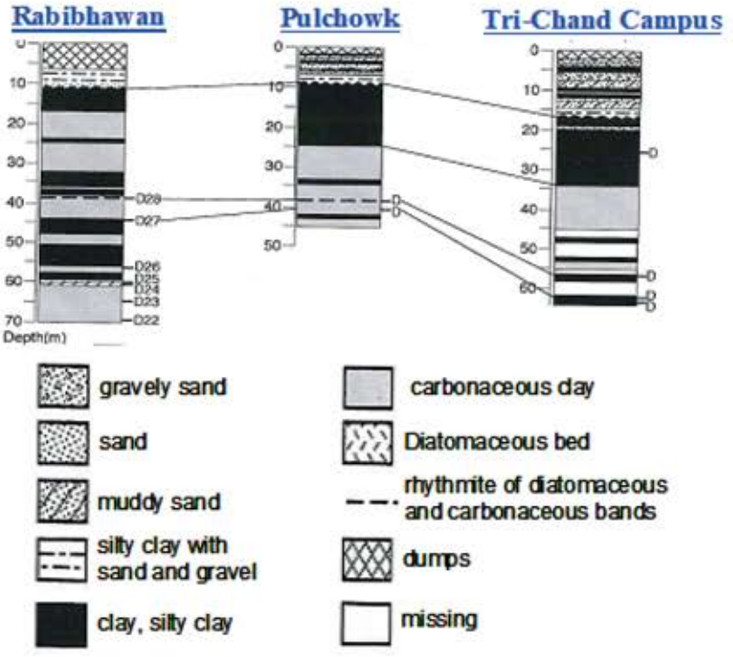

Figure 2 Typical soil profiles of central area of the Kathmandu Valley (Sakai et al. 2001)

3. Tunnelling in Kathmandu soil

Considering the city's urban density, limited public urban space, historical significance, local soil and geology, the development of a network of bored railway tunnels is more appropriate than elevated railway networks in the core urban area and this is also technically feasible. About thirty percent of surficial area is judged to be highly susceptible to liquefaction during an earthquake (Piya 2004). In these circumstances, underground structures such as tunnels would be inherently robust and economical to build.

In the proposed metro map shown in Figure 3, the central part of the routes within or around the Ring Road will be built underground. Thus, the proposal is to build the section of Patan Line (Satdobato to Bansbari), Kathmandu Line (Kalanki to Bouddha and Koteshwor), Bishnumati Line (Balkhu to New Bus Part) and the whole Chakrapath Line through bore tunnels.

In the light of the extant subsoil and geological conditions, a review of various underground metro developments around the world and various other governing factors, twin bore tunnels of 6.0m external diameter at a depth of around 25m below ground level would be appropriate in Kathmandu. A single tunnel carrying twin tracks would require an 8m external diameter at 45m. Such diameters and depths would cause minimal vertical and differential settlement at the surface level and thus be expected to cause negligible damage to the surficial properties/buildings located along the tunnel alignment. Such dimensional details are established by limiting vertical settlement to less than or equal to 10mm and differential settlement to 1:500. Modern tunnel boring machine (TBM) could easily bore such diameter tunnels. Additionally, the following equations and parameters (See Table 3) are adopted for deriving above dimensional details:

Figure 3 Map of the proposed railway network for Kathmandu Metro

$$i_y = K.z_o \quad (1)$$

Eq. 1 is as per O'Reilly and New (1983).

$$W_{max} = 0.0125.V_l.(r^2 / i_y) \quad (2)$$

$$\theta_{max} = 0.607.(W_{max} / i_y) \quad (3)$$

- where;
  - i_y = distance from tunnel centre-line to point of inflextion
  - K= a constant which depends upon soil type
  - Z_o = depth from surface to tunnel axis
  - V_l = The percentage volume lost
  - r = radius of tunnel
  - W_{max} = The maximum settlement at surface
  - θ_{max} = The maximum slope of the settlement trough

Table 3 Tunnelling parameters adopted for the recommendation of tunnel size and depth

Parameters	Input Value
Volume Loss Parameter (%): Closed face tunnelling using TBM	1.5
Trough Width Parameter (K): Recent silty clay deposits	0.7

A shallower depth of tunnels for the above mentioned diameters would still be possible. However, potential ground movement needs to be quantified, controlled and minimized with proper design and construction techniques. It is possible to establish a zone of influence (band width) along the proposed tunnel route and around the vicinity of deep excavations. For example, for the running tunnel diameter and depths mentioned above, the zone of influence could be about 35m (for 6m diameter tunnel) or about 70m (for 8m diameter tunnel) on either side from the centre line of alignment. See Figure 4. It is essential to carry out surveys of existing buildings, such as type of building, its use, height, size, structural and foundation features, and utility services within the zone of influence to enable the assessment of potential damage due to the tunnelling. Such surveys will be ultimately invaluable to refine a design and enable the necessary precautions and preventive measures to be put in place prior to and during the underground construction.

The black silty clay, which predominates throughout the Valley's subsurface, is of firm to stiff consistency and is an ideal medium for tunnelling. With the availability of various kinds of TBM on the market, the construction of tunnels is not such a complicated and difficult job as it used to be. Modern technology comes with tunnel lining systems and tunnels can be quickly built using concrete segment panels. However, a larger tunnel is envisaged for local underground stations. In this case, the same running tunnel can be enlarged to a relatively larger internal diameter such as 6.5m to 7.0m for about 75m length to accommodate platforms. Sprayed concrete lining techniques may be appropriate for tunnel support. What needs to be done immediately is to delineate the route in the city and prevent the further evolution of high-rise buildings in the tunnel influence zone. Further delay in the process may require future tunnels to be much deeper than prescribed above. The above vision of going below the surface for the metro development is necessary and such a vision is equally applicable for development of the city's other vital infrastructure such as drainage, water supply, power-grids and communication.

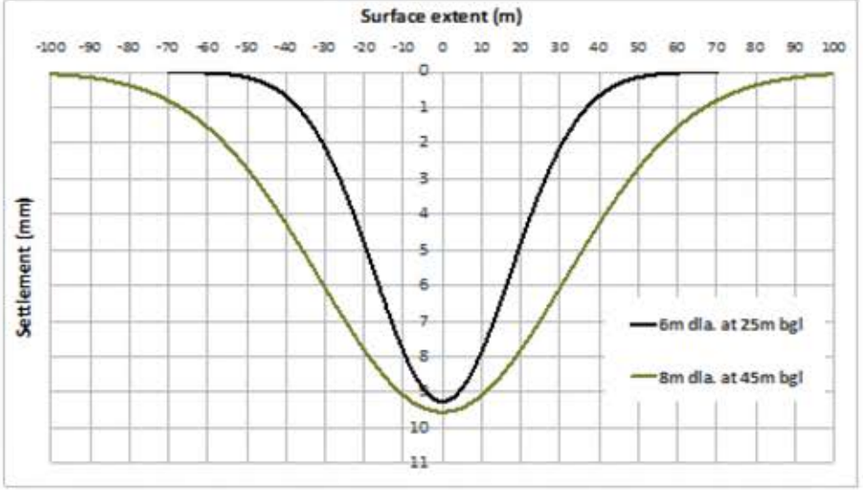

Figure 4 Ground surface settlement due to tunnelling

4. Underground metro stations in Kathmandu soil

Nine major underground stations (mega stations) are proposed within and around the area of the Ring Road such as Bhrikuti Mandap, Tankeshwor, New Bus Park, Bansbari, Bouddha, Koteshwor, Satdobato, Balkhu and Kalanki. See the proposed idealised railway map Figure 5 for the location of these proposed stations.

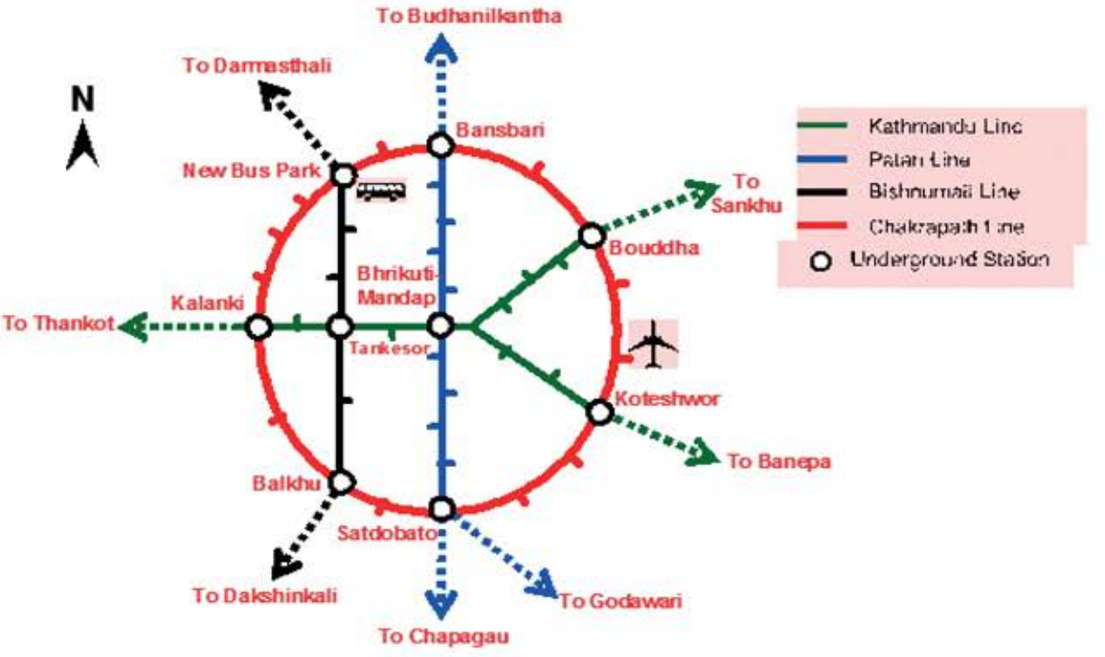

Figure 5 Idealised map of the Kathmandu Metro (Underground section)

These stations should be relatively large, multi-storey underground structures that serve as transit points for the Metro. See Figure 6 for a schematic sectional view of major underground stations.

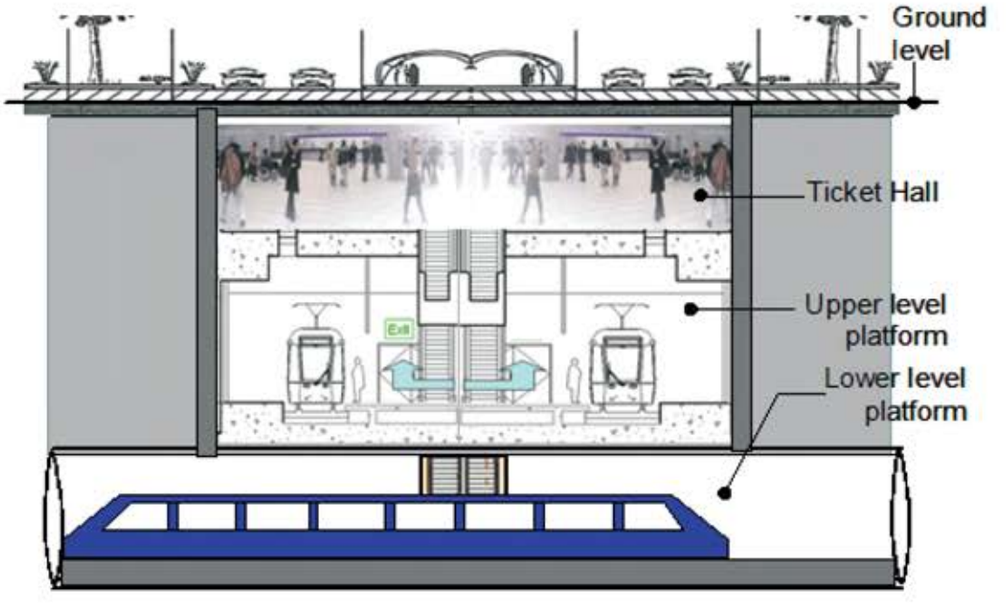

Figure 6 Schematic sectional view of major underground station (Mega stations)

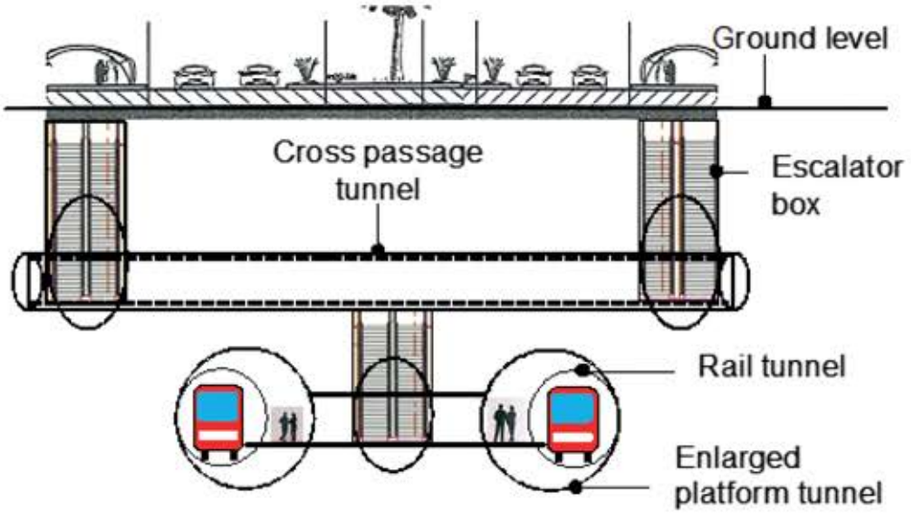

Figure 7 Schematic sectional view of local underground station

These mega stations should be about 2 to 6 km apart, will be 2 to 3 storey underground buildings (See Figure 6), and can be built by adopting a 'top-down' construction technique. Such a technique would cause less disruption to the adjoining area. Construction of such underground structures will be expensive, laborious and will require advanced construction techniques so it is essential to build such mega stations in a limited numbers (nine only) and use them prudently. Based on local need, local underground stations can be built at a distance of about 0.5 km to 1.5 km at various locations. The local underground stations located within the urban core area can be built with adequate space by slightly enlarging the proposed metro tunnel with a platform integrated within it. See Figure 7 for a schematic sectional view.

5. Challenges of the ground conditions in the Kathmandu Valley

Ground engineering is the backbone for any civil engineering construction since any structures to be built rest on ground. However, this field is very complex in nature since ground is not well-defined material such as concrete or steel. Thus, without thorough geotechnical investigations, ground engineering works present a hazard. Management of geotechnical risks caused by such hazards are very important for success of any civil engineering projects, especially for an underground construction project such the metro. Geotechnical risk management is most effective when started as early as possible. Lack of attention to the geotechnical hazards could give rise to many risks involving for example technical, financial, contractual, commercial, health and safety issues as well as environmental and sustainability risk. These risks can be only managed through the use of adequate geotechnical expertise and adequate ground investigation works.

Construction of a multi-storey underground railway stations in Kathmandu soil will be a challenging job because very limited ground information of the Valley for engineering design is available in the public domain. Due to predominant fluvial deposit at shallow depth, the ground is very heterogeneous and less competent. R&D on the ground improvement technology appropriate for the soil conditions of Kathmandu is therefore necessary. An initiative is required to create a 'Global Ground Investigation Data Based System' by compiling all the available data from the geo-consultants of Nepal.

Kathmandu and whole of Nepal lie in the Himalayan seismic active zone, so a study of the activities of fault lines within and around the Valley is recommended. Any underground and overground structures to be built in the region are to be seismic-resistant. Development of the design code of practice for the underground structures for the region is a timely need and lessons can be learnt from Mexico City Metro, Los Angeles Metro, and Tokyo Metro in order to develop a robust underground rail infrastructure in Kathmandu.

An effort is underway for a joint research collaboration between Warwick University, UK and Institute of Engineering (IOE), Tribhuvan University, Nepal with a support from the local industrial partners - MULTI Disciplinary Consultants (P) Ltd and ITECO Nepal (P) Ltd to investigate construction of underground metro structures in the ground condition of Kathmandu. It is anticipated that this research will result in many useful findings appropriate for the construction of tunnels and underground stations in the local context.

6. Conclusions

The Metro rail network is the sustainable solution for keeping the Kathmandu city moving for the present and future. Such development is a timely response to the need for regeneration of the Capital and for ensuring economic prosperity of the region, delivering real changes. The proposal is to develop sections of Kathmandu Line, Patan Line, Bishnumati Line, Chakrapath Line located within and around the Ring Road by constructing bored tunnels. For such development, nine major underground stations (mega stations) are proposed within the central urban core covered by the Ring Road.

The ground condition in the valley is challenging due to lacustrine deposits and the region lies in the Himalayan seismic active zone. However, tunnels and other underground structures could be designed and built robustly for such ground conditions. Tunnelling would be the best option for a metro rail in the core urban area. Lessons can be learnt from the metro development in seismically active regions and soft ground conditions such as Mexico City Metro, Los Angeles Metro, Tokyo Metro, Bangkok MRT.

Very limited ground data of Kathmandu soil for engineering design/application is available in the public domain and R&D on Kathmandu soil is seriously lacking. There is so far also very limited understanding of the ground condition and engineering behaviour of Kathmandu soil and geology. Limited understanding of the ground condition is a huge risk for construction of any type of underground structure. Thus, urgent studies on the behaviour of Kathmandu soil is necessary for the success of the underground metro rail.

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Importance of a Robust Engineering Assurance Process and iELC for Railway Infrastructure Projects

Narad Bhandari

Lead Senior Project Engineer, Network Rail, London, UK

naradbh@yahoo.com

1. Background

Engineering is the application of science and technology to meet the "needs" or demands of the society. The role of an engineer is to respond to a requirement by creating or building something with a certain set of specifications to perform a given task. An engineer, as a professional, has a responsibility to their employer or client, to their profession, and to the public, to perform their duties as reliably as possible. Hence, the engineer must act in such a way as to avoid failure of the user of their creation or technology, and, more importantly, catastrophic failure which could result in loss of property, damage to the environment, and possibly loss of lives. Through analysis and study of past engineering disasters, modern engineering designs and constructions can be performed with low chances of failures.

The followings are usually considered the primary causes of engineering disasters:
- human factors, including ethical failure and accidents
- deficiency in designs
- materials failures
- extreme conditions or environments (both preventable or non-preventable), and
- combinations of above reasons

A study conducted at the Swiss Federal Institute of Technology in Zurich [1], where 800 cases of structural failure analysed in which 504 people were killed, more than 590 people injured, and huge financial damages incurred. The following causes of failure were classified by the researchers when engineers were at fault:

Table 1: Causes of Structure Failure when engineers were at fault (Matousek and Schneider, (1976)

Causes of structure failure	Contribution
Insufficient knowledge	36%
Underestimation of influence	16%
Ignorance, carelessness, negligence	14%
Forgetfulness, error	13%
Relying upon others without sufficient control	9%
Objectively unknown situation	7%
Imprecise definition of responsibilities	1%
Choice of bad quality	1%
Others	3%

Engineering is based on human thinking and therefore it is prone to error and failure. Engineering design process often entails fatal errors. We must learn from past mistakes, and the engineering community should incorporate lessons learned from engineering disasters to at least avoid the same kind of failure happening again. Table 2 provides some of the major disasters happened in the history and lesson learned from the failures (Chawla (2007), Schlager (1994), Petroski (1994) and NASA (2009).

Table 2: Some of the major disasters in the history of Engineering

Disaster	When	Loss of lives	Main Cause of Failure	Lesson Learned/ Improvement
Sinking of the Titanic Ship	15th April 1912	1500	Multiple rivet and steel hull failures upon collision with iceberg due to Titanic steel was extremely brittle at water temperature.	Modern Steels have much higher toughness and lower Ductile-to-Brittle Transition Temperature (DBTT).
Explosion of Chernobyl Nuclear Power Plant	25th April 1986	31	The plant was not designed to safety standards, and incorporated unsafe features.	Safety standard and safety culture improvement. Plant safety design improved.
Clapham Junction Rail Crash (Collision) - A passenger train crashed into rear of another train that had stopped at a signal.	12th Dec 1988	35 deaths, 484 injured	Signal failure caused by a wiring fault in track circuit. New wiring had been installed, but old wiring left connected, caused false feed to relay system.	Signalling technicians training, competency, assessment and testing & inspection has now been improved and mandatory supervision and monitoring requirement implemented.
Ladbroke Grove Train collision (near London Paddington)	5th Oct 1999	31 deaths, 523 injured	Signal passed at danger (SPAD) due to signal obstructed from driver's sight – signal poorly sighted (location issue).	Signal sighting process now improved at design, implementation stages. Safety procedures and Drivers training also improved.
Explosion of the Space Shuttle Columbia - the Space Shuttle disintegrated during its re-entry to the Earth's atmosphere.	1st Feb 2003	All 7 crew members	Structural failure of left wing damage from debris impact during launch. NASA deviated from design criteria - was not designed to withstand significant impacts.	Need to increase shuttle ability to sustain minor debris damage; After flights, more frequent inspections of leading edge should be conducted; Impact of foam should be addressed.
Wenzhou (China) High Speed Rail crash – collided on a viaduct and four cars fell off the Ou River bridge to the ground 20m below	23rd July 2011	40 deaths, 210+ injured	Signalling failure due to sever defects in the design of signalling control equipment, Chinese Train Control System CTCS-2.	Chinese government had suspended their signalling system equipment. Design on control equipment improved. Speed of HSR reduced than designed.

Various lessons learned reports indicate that one of the major constituent of engineering failure is quality of design production and construction activities due to lack of good engineering process [2, 3, 4, 5]. Most of the engineering industries follow some form of assurance activity, but not all have a robust engineering assurance process, some are relied entirely on a design organisation, and not having their own structured project engineering assurance process in place within their project management activities.

2. Engineering Assurance Process for Infrastructure Projects

In general practice, an Engineering Management Plan (EMP) is set up within the organisation, which outlines the base strategy for all engineering activities, including Engineering Assurances for the Projects. The Engineering Assurance Process (EAP) describes a process for performing the engineering activities independent of any of the constraints of any specific organisational structure. The EAP for the Infrastructure Projects is applied at project level using project engineering resources. Any specialist resources required for supporting engineering assurance activities can be brought from programme level or wider organisation pool of resources.

2.1 Importance of a Robust Engineering Assurance Process

Appropriate governance, project management, financing and quality assurance processes must be in place in their organisational management to enable projects to complete their specified activities effectively and efficiently. Through a robust EAP a project or product can be developed and delivered effectively in line with all relevant standards and processes, which provides the client with confidence, reduces project and safety risks, and help ensure that a completed project or product not only meets the project requirements, but also optimise the balance between quality, time and cost. The Figure 1 below illustrates the importance of the right proportions between these key constituents for a successful project.

Figure 1: Balance between Quality, Time and Cost for a Successful Project

An Integrated Engineering Life Cycle (iELC) (ISO/IEC/IEEE 15288:2015 and Gedge, 2017) tool has recently been developed for conducting engineering assurance process in infrastructure projects for Network Rail, owner and maintainer of government-owned railway infrastructures in the United Kingdom to improve quality of design and construction activities, which is elaborated in more detail in subsequent sections below.

3. Integrated Engineering Life Cycle (iELC)

The iELC intends to enable more successful delivery projects by ensuring completion of the right engineering activities at the right time; providing a common reference and an integrated system, assurance and control approach for engineering activities and processes. This approach provides better relationship between Project Management and the Project Engineering activities as part of continuous improvement in managing engineering processes. For the complex and multidisciplinary projects, the Network Rail has started implementing the iELC process to fulfil the commitment they made to the Office of Rail and Road (ORR), independent government regulatory body of the United Kingdom, to improve their engineering processes. iELC outlines how project activities, including the relationship to non-engineering activities are tied together, including:

- How iELC phases align to Project Life Cycle stages.
- Engineering input into project planning.
- Project Risk & Value Management.
- Project inputs to Cost Planning & Estimating.

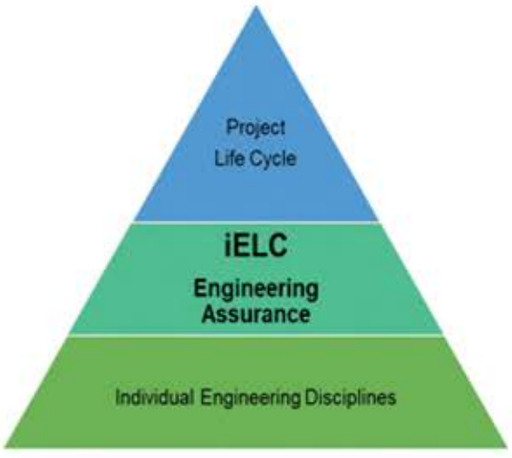

Figure 2: iELC Engineering Assurance Relationship to Project Life Cycle.

3.1 Engineering Phase Gate and Relationship with Project Life Cycle

An Engineering Phase Gate sits between each of the iELC phases. Each Engineering Phase Gate includes several questions to help ensure the required activities and deliverables are complete before projects proceed to the next phase. The Engineering Phase Gates are undertaken based upon the projects Level of Control (LoC). Each Engineering Phase Gate includes a number of questions, which were developed from BS ISO/IEC 15288:2015 'Systems and Software Engineering – System Lifecycle Processes' (ISO/IEC/IEEE 15288:2015 (2015)) to ensure all technical aspects required throughout the lifecycle of a project are included. These questions have been supplemented with railway specific aspects such as Common Safety Method (CSM) and Technical Specification for Interoperability (TSI).

The iELC is part of the tool kit demonstrating that the project is delivering against its requirements. The iELC Engineering Phase Gates help to highlight gaps in the project information from an engineering perspective. The Engineering Phase Gates provide a periodic review of project status, and confidence to the senior management of Infrastructure Projects. The iELC consists of six engineering phases (A-F) which align with the Project Life Cycle stages (GRIP, Governance of Railway Infrastructure Projects, stages for Network Rail Projects, or RIBA stages in Built industries). These cover the whole of the Project lifecycle and describe an integrated systems approach for the engineering activities and deliverables undertaken by the engineering disciplines.

The Project Lifecycle for Network Rail Projects is split into eight stages (GRIP Stages 1-8). The relationship between Project Life Cycle stages and the Engineering Phases is illustrated in Figure 3. Most of the Engineering phases are directly aligned with the Project Life Cycle stages, however Phase B covers Stage 2 and part of the Stage 3, whereas Project's single option development (Stage 4) can only be completed once technical single option developed and detailed requirement finalised.

Eng. Phase A Concept	**Eng. Phase B** Option Definition & Selection	**Eng. Phase C** Single Option Development	**Eng. Phase D** Detailed Requirement	**Eng. Phase E** Detailed Design	**Eng. Phase F** Implementation

PROJECT LIFE CYCLE TIME LINE

PLC Stage 1 Output Definition	**PLC Stage 2** Feasibility	**PLC Stage 3** Option Selection	**PLC Stage 4** Single Option Development	**PLC Stage 5** Detailed Design	**PLC Stage 6** Construction, Testing & Commissioning	**PLC Stage 7** Project Handback	**PLC Stage 8** Project Closeout

Figure 3: Relationship between Project Life Cycle (PLC) Stages and Engineering Phases

Phase A – Defining the requirements for the project, through the Client Requirements Document (CRD).

Phase B – Identifying a set of options, through to selecting a single option at the end of the phase for scheme outline design development.

Phase C – Developing the single option design to Approval in Principle (outline/scheme design), to both support the individual discipline sign off, as well as ensuring there is sufficient detail for the required cost certainty at the end of project GRIP stage 3.

Phase D – Defining the detailed requirements for the project, through the production of Detailed Requirements Document.

Phase E – Detailed design, and ensuring the project is ready for the construction / installation at the end of project GRIP stage 5.

Phase F – Construction / Fabrication / Installation activities. Then followed by the testing, commissioning, Entry into Service and handback.

In addition to the Engineering Phase Gate questions, an assessment is undertaken using the Project Categorisation Tool (PCAT) to assist a project at the beginning of each engineering phase, which generates an indicative project specific deliverables list. At the Engineering Phase Gate review, the products (specifications, drawings, assessments, reports, etc.) of the engineering activities are compared with the deliverable list in order to verify how healthy the project is. The format for the Engineering Phase Gate Questionnaires checklist may be in any form or format, an example could be as below.

Table 3: Example of questionnaires for Engineering Phase Gate E (Detailed Design)

Phase Gate & Q. No.	Review Question	Source Location	Engineering Action	Evidence	Justification	Outcome (RAG Status)
Phase E – No.1	Is the detailed design at a sufficient level and completeness to support implementation?	Detailed Requirement Document	Input & Review	Specifications, Drawings and V&V matrix	All required specifications and drawings are in place	**Green**
…	…	…	…	…	…	…

Some of the supporting Questions to the above "Review Question" may be followings:

- Have detailed design outputs been produced for each discipline?
- Where residual risks are identified is there evidence to demonstrate how the Principles of Prevention have been applied to reduce these risks to acceptable levels?
- Is the detailed design output in a suitable format to adequately support procurement, construction & installation and testing & commissioning?
- Is it clear that the completed designs fulfil the defined performance requirements which have operational and/or maintenance dependencies?
- Have the various elements of the detailed design been integrated? etc.

3.2 Engineering Assurance Team and Working Relationship with Designer

At the beginning of a project an engineering assurance team needs to be assigned to the project to carry out the necessary assurance activities. The structure of an engineering assurance team for a railway infrastructure project can be as shown in Figure 4. A Lead Project Engineer (e.g. DPE – Designated Project Engineer for Network Rail projects) is appointed for a project to lead the acceptance of engineering designs. The Lead Project Engineer is accountable for the coordination and integration of technical and engineering activities of the multidisciplinary project. Project Engineers, accountable to the Lead Project Engineer, are appointed to the project for managing project engineering and assurance activities for their engineering disciplines. In order to provide complete assurance to a project other specialist resources may also need to be appointed.

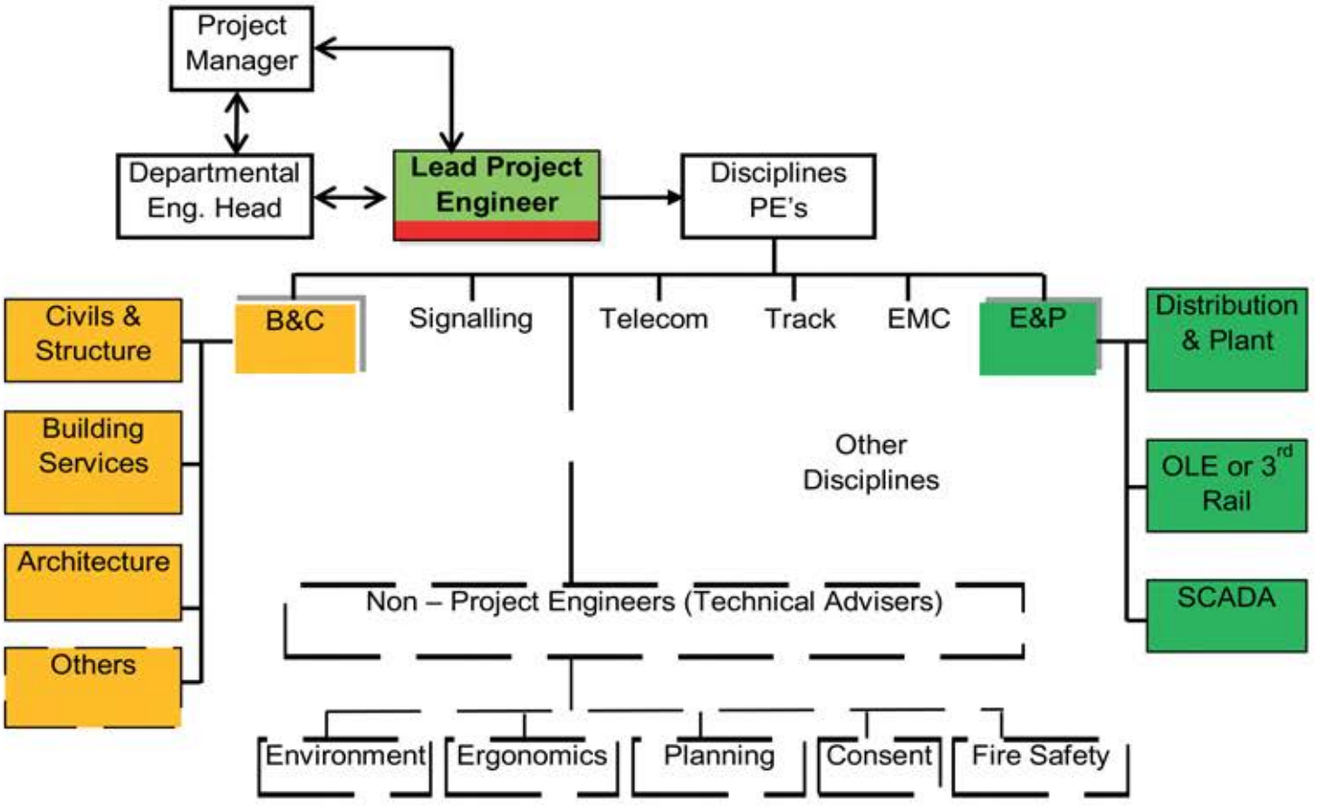

Figure 4: Example of an Engineering Assurance Team (Railway Related)

Once a Design organisation or contractor is in place they also need to allocate roles and responsibilities by appointing their Lead Engineer and discipline design engineers, whose competencies be normally reviewed and approved by the project engineering assurance team.

During the design development the project assurance team and the designer team need to work collaboratively through the effective engagement and communication (see Figure 5) to minimise risks, improve design quality and smoothen review and acceptance activities.

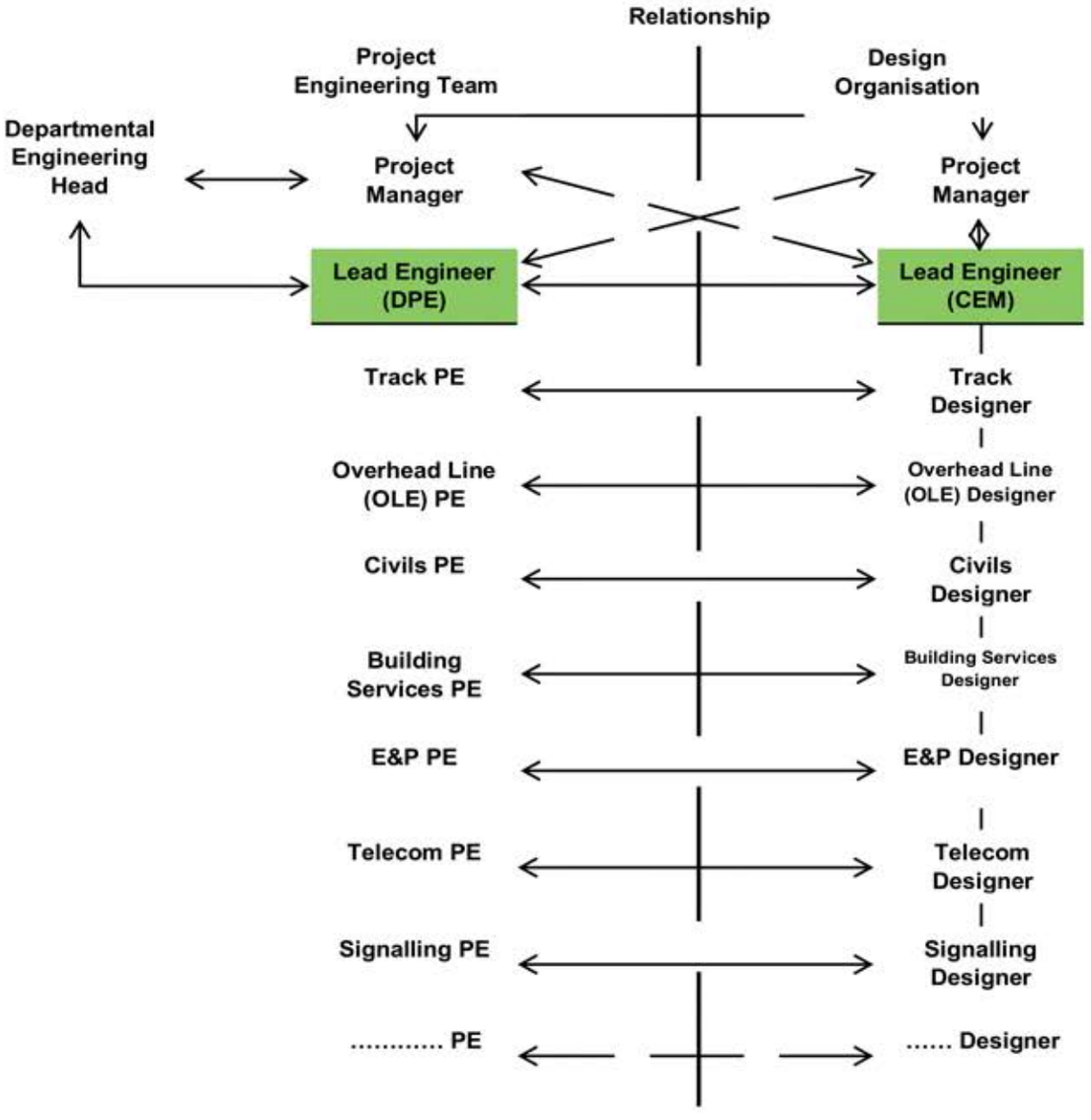

Figure 5: Collaborative working relationship between Project Engineering and Designer Teams

3.3 Engineering Review and Approval Process

A Technical Assurance Plan (TAP) sets out the method for providing technical or engineering assurance of the Projects. It covers the roles and responsibilities for reviews and approvals during design, construction and handbook in order to provide technical assurance. A Design Review and Approval Procedure is set up for undertaking design acceptance as shown in Figure 6. The procedure also standardises the Document Review Notice or Report format, reporting and action planning, categorisation of review comments and quality metrics. The process for assuring the engineering designs and construction is built around the following parameters:

- A project life cycle stages and engineering phase gates
- The outputs from the project stage gate review
- The controls for successful completion of a stage

Combining these gives a methodology for assuring outputs through the stages of the project by monitoring the input and process controls.

The Project Engineers are responsible for conducting review and acceptance for their respective engineering disciplines. The Lead Engineer (e.g. DPE) is responsible for completing, monitoring and controls of technical assurances and Engineering Phase Gates, and supporting the Project Manager in Projects Stage Gates reviews. A Systems Engineer can be appointed to support the Lead Engineer (DPE) and Project Manager for managing safety-related activities, e.g. Project Hazard Logs and Records and system configuration management.

An Acceptance Review is conducted for all engineering deliverables. The Acceptance Review is facilitated by the Lead Engineer (DPE) and undertaken by the respective engineering discipline Project Engineer, who produces a Review Report or Notes. Once all the disciplines reviews are completed and coordinated each other and interdisciplinary review satisfied, the Lead Engineer performs the Engineering Phase Gate Review, which then feeds into the overall Project's Stage Gate Review for final approval and endorsement by the Stage Review Panel. The Project is not allowed to proceed further until the appropriate Stage Gate Review is successfully endorsed.

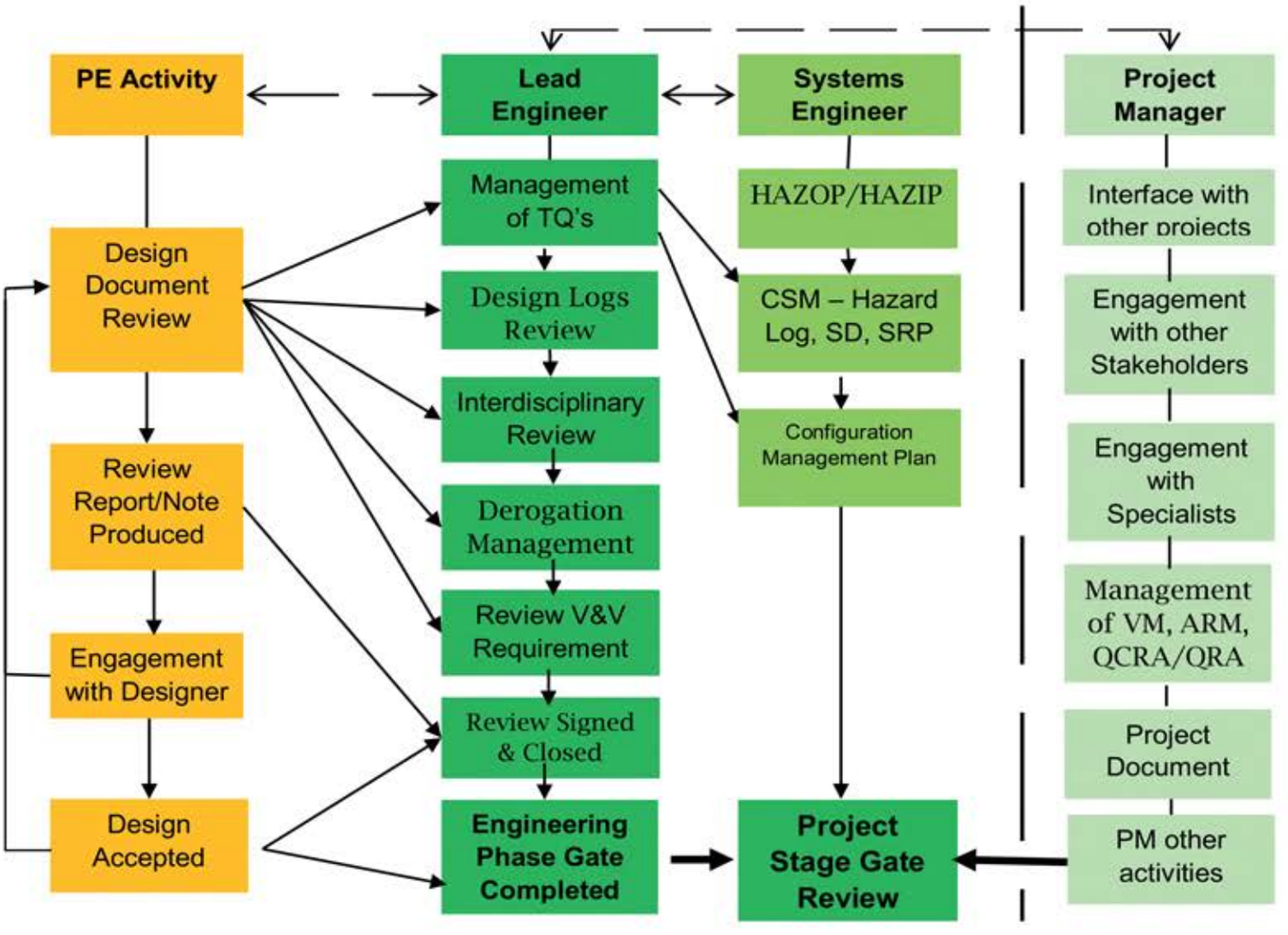

Figure 6: Engineering Assurance Review and Approval Process

4. Conclusions

A robust Engineering Assurance Process, like the iELC helps to minimise the engineering risks and identify gaps in the project deliverables information from an engineering perspective. The Engineering Phase Gates perform a periodic review of project status, and provides assurance to the senior management. The Engineering Phase Gate questions include some that are forward looking i.e. is the project ready to start the next phase? Some questions are 'open', so rather than a tick box exercise, the process helps determining if sufficient detail has been produced to support the project, and thus smoothens the process for achieving the overall project's acceptability for further development and successful implementation.

The implementation of an effective Engineering Assurance Process minimises the project risk from engineering failures. The iELC process and activities can be tailored to suit to any engineering industries and implemented similar process effectively.

5. Recommendation for Infrastructure Development in Nepal

Most of the major Infrastructure Projects in Nepal entirely depend on foreign or private investors. The design and construction of these projects are carried out primarily by their own design and built contractors or through their selective consultants or contractors. Government of Nepal and its sister organisation do not have full visibility of what Engineering Assurance activities are undertaken by them. This may lead to engineering disasters if compromise in engineering design or construction activities were taken by them, and to insufficient capability in maintaining and operating the infrastructure by the Government of Nepal in long term.

The Railway System consists of very complex and multidisciplinary infrastructures with many constraints and limitations. Therefore, the structure of Engineering Assurance Team, Review and Acceptance process discussed in this paper and iELC-like tool can be implemented for any future Railway Infrastructure development in Nepal to minimise projects risks during design, construction, operation and maintenance. The conceptual methodology of this process can also be implemented in other engineering infrastructure development in Nepal.

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Schematic Design of Dodhara Chandani Pedestrian Suspension Bridge

Krishna Kishor Shrestha

Senior Roads Renewal Engineer, Jacobs, UK

kk_shrestha@hotmail.com

1. Introduction

Mahakali River is a border river between Nepal and India in the west (Figure 1), which isolates the two village development committees (VDCs) Dodhara and Chandani from the Mainland of Nepal. There is no permanent link to cross the wide river between the mainland and the two VDCs. This has necessitated constructing a pedestrian crossing (suspension bridge) over the 1400 m wide River. This bridge with length of 1453 m claimed to be the longest pedestrian suspension bridge of its kind in the world.

Figure 1: Map of Nepal and Location of the bridge (Wiki file, 2005)

In 1999, Department of Roads (DOR) commissioned the feasibility study of Dodhara Chandani Suspension bridge project but did not approve the proposed options of the feasibility study: multi span continuous suspension bridge and cable car system. Both options were not feasible according to the objective of the crossing. Hence, DOR instructed to the consultant NEPECON in association with Highway Nepal to find other suitable option within types of suspension bridge crossing, which is simple to construct and simple in operation. The study proposed a serial suspension bridge which was later revised by Suspension Bridge Division (SBD) and constructed by Department of Local Roads (DoLI) in 2005. This paper shows how an exploration of various 'Non-standard Solutions' combined with creativity and innovation could bring the right choice of the schematic design of civil engineering structures. This paper describes background of the project and details the desktop study carried out to select serial suspension bridge as the design option.

1. Background

Pedestrian suspension bridges are very popular and affordable crossings over numerous rivers of Nepal. Steel cables are used for spanning for both suspension and main cables. They are easy to build and cheaper in remote areas where motorable roads are not reached. In 1999, Department of Roads finalised the feasibility study of Dodhara Chandani Suspension bridge project with two different structural systems for the 1200m wide river crossing: A Cable Car system and a Multi span continuous suspension bridge along the identified bridge axis (Figure 2) about 1.8km downstream Sharada Barrage.

Figure 2a & 2b: Bridge site plan (Department of Roads, 1999)

1.1 Cable Car system

Cable Car system is with bi-cable, 2 spans of 630m each and 2 numbers of cars for each way (Figure 3). Cable car system is cheaper initially, but its operation and maintenance are difficult. Day to day management of such operation and maintenance would not be possible without any financial support. There is no policy for charging locals for bridge crossing. Hence, this cable car option is not feasible due to financial and operation issues.

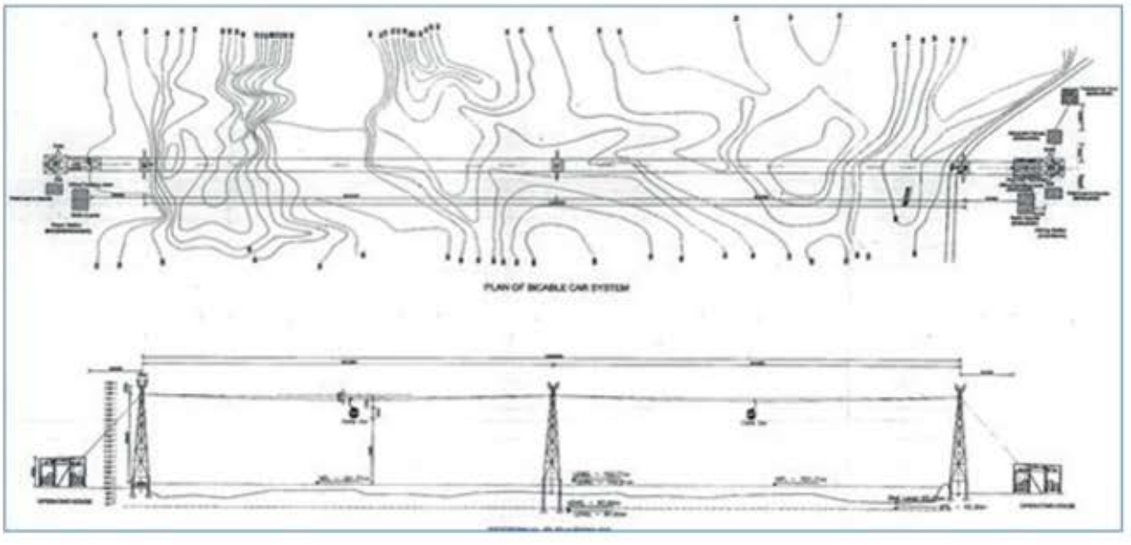


Figure 3: Cable car system (Department of Roads, 1999)

1.2 Multi Span Continuous Suspension Bridge

Multi span suspension bridge consists of 5 spans of 244.46m each with additional stabilizing cables and it is continuous through length with anchorages at both ends (Figure 4). Multi-span continuous suspension bridge would be of a good choice despite of huge initial cost if there were sufficient worked out for structural analyses for complicated continuous spanning. Not many past experiences on multi-span continuous suspension bridge are available. Due to uncertainty of performance of structural system of continuous type spanning, the authority could not take risk on the multi-span continuous option either.

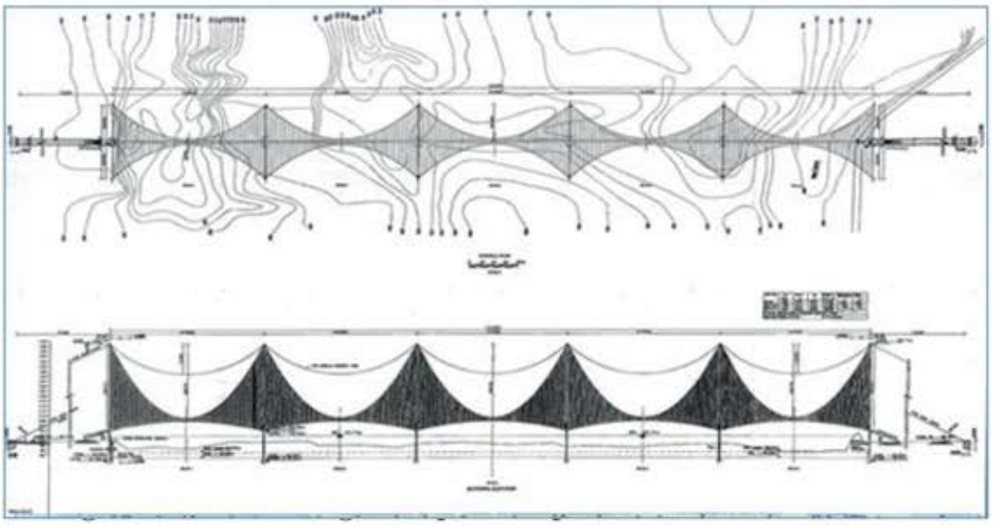


Figure 4: Multi-span continuous Suspension bridge (Department of Road, 1999)

1.3 Discussions on Multi Span Continuous Pedestrian System

The possible options are limited as stated in the main requirements. The only option considered at the time, was multi-span continuous spanning structural system for suspension bridge as in the feasibility study. Long span (3 span with longer middle span) suspension bridges could be possible alternative as in the spanning system of motorable bridges. However, the following issues were raised for the adoption of multi-span continuous and long span suspension bridges to narrow width of pedestrian way (footway) and wider river crossing in a plain area.

Structural viability of various options of multi-span continuous spanning was discussed.

- Multi span of 5 x 244.6m, which was proposed in the feasibility study. This is 5 equal spans of 244.6m with tower pivoted at the base. This system has increased flexibility larger deflection under asymmetric load. Also, longitudinal displacement of the central tower top (swaying) is much more than in conventional three span suspension bridge.

- Another variant is 70m+4x225m+70m. It is with 4 main equal spans and 2 side spans. This system is continuous with fixed column type tower to piers. But large cross-sectional dimensions of towers, piers and foundations would require giving equal displacements as this will lead to additional construction cost.

Some notes on multi-span continuous suspension bridges for narrow cross sections:

- Only a few multi-span suspension bridges have yet been constructed
- Structural behaviour not so much explored
- Rare in practice (usually single span in Nepal)
- No local competence on design and construction
- In terms of narrow bridge safety of aerodynamic stability is in question
- Not many past experiences available
- Structural behavior not so much explored - Complicated structural analysis and deflection on multi-span continuous lead to uncertainty of its performance and safety
- Large cross-sectional dimensions of towers, piers and foundations would require for equal displacements – Expensive

Some notes on long-span (3-span system) suspension bridges for narrow cross sections:

- Slenderness ratio (width to span) – for 1400m main span with 1.6m width, the slenderness is ratio 1/875, which is very much slenderer if compare with Golden Gate, USA (1/168) and Hardanger, Norway (1/72) (Myerscough and Hayward, 2013)
- Large cross-sectional dimensions of towers, piers and foundations - Expensive

2. Scope of Further Study

The scope of work was further redefined (narrowed down) after the completion of the feasibility study of the Multi Span Suspension Bridge over Mahakali River. The challenge was to find an innovative solution for the bridge crossing, which satisfies the following three main requirements along with the whole life economic cost. The main requirements stated are as follows:

- The proposed pedestrian bridge should be economically viable and affordable.
- It should be permanent type (all weather) suspension bridge crossing.
- It should be simple to construct, use, operate and maintain.

3. Research on Spanning System of Motorable Suspension bridges

The bridge crossing site is 1200m wide, flat and open area. Careful engineering judgement required for design consideration. Many schemes studied were for motorable suspension bridges. Adoption of any scheme from vehicle bridges to pedestrian one is not simple. Hence, after study of many systems of suspension bridges, the author came up with a hope of possibility of adoption of structural scheme based on examples of two well-known motorable bridges, viz.,

- Kurushima Kaikyo Three suspension bridge in Japan
- San Francisco Oakland bay bridge (Western segment – Suspension bridge)

3.1 Kurushima Kaikyo Three Suspension Bridge in Japan

The Kurushima Kaikyo Bridge consists of three suspension bridges with a total length of 4,105 m connecting Imabari city and Oshima Island and crossing the Kurushima Strait in Japan. The details of spans and length of all three bridges are given below in the Table 1.

Table 1: Details of span and lengths of Kurushima Kaikyo Three Bridge

Bridge No.	Total length	Centre span	Connecting
1st	960 m	600m	Oshima island
2nd	1515m	1020m	Bushi, Kobushiand Majima islands
3rd	1570m	1030	Imabari side

Each two of three suspensions bridges are anchored to the mid pier and deck is continued with simply supported structure over pier (each 30m wide) as shown in Figure 5. This experience shows that serial suspension bridges joined with a certain simple structural system could be used for spanning wider waterway. Performance of such structural scheme is known and experienced in many bridges.

Figure 5: Kurushima Kaikyo three suspension bridges (https://commons.wikimedia.org/wiki/File:Kurushima_Kaikyo_Bridge-3edit.jpg)

3.2 San Francisco Oakland Bay Bridge in USA

The San Francisco Oakland bay bridge consists of two major segments connecting a central island, Yerba Buena Island, with each shore San Francisco on the west and Oakland on the east (Figure 6). The eastern span terminating in Oakland consists of four distinct structures, a short low-rise span connecting the Oakland shore to the bridge, the Skyway Bridge - the low-rise span to the suspension segment, the single-tower self-anchored Suspension (SAS) Span and a box-girder roadway connecting the Suspension Section to Yerba Buena tunnel. The western segment terminating in San Francisco consists of two suspension bridges end-to-end with a central anchorage (Figure 6). The 2850m long western span of the bridge presented an enormous engineering challenge, which led to build two complete suspension bridges, one on either side of the central anchorage (designed by LS Moiseiff).

Figure 6: Western segment of San Francisco Oakland Bay Bridge (Collings, 2016)

In this bridge the anchor pier joins two independent suspension bridges. From this experience, the concept of anchor pier can be adopted for the structural scheme of spanning wider river in our case. The final solution was to essentially construct a man-made island in the middle of the bay that would serve as an anchor for the suspension spans.

4. Innovative Spanning System Proposed

The new scheme consists of three serial Three-span simple suspension bridges (Figure 7), which are connected by simply supported systems and cables are anchored in two mid piers and on both river banks. Three-span simple bridge is with externally anchored i.e. not self-anchored suspension (SAS) type.

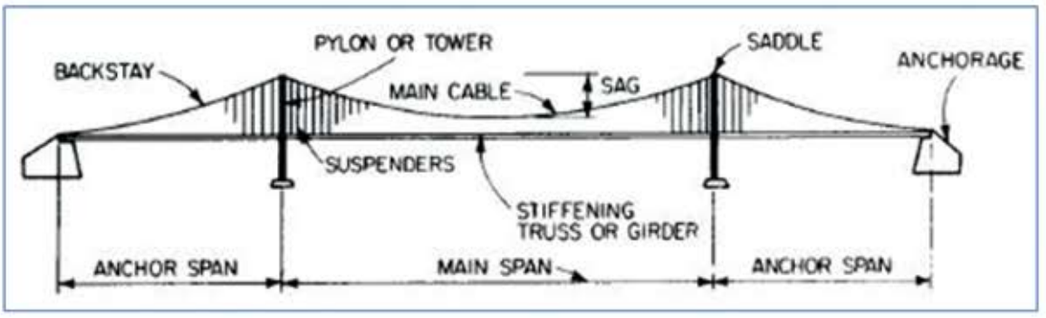


Figure 7: Three-span Simple Suspension Bridge (http://www.civilengineeringx.com)

The innovative solution to pedestrian suspension over wide river crossing was combination of two concepts drawn from above mentioned examples:

- Joining serial simple suspension bridges with simply supported structures - Concept of Kurushima Kaikyo three suspension bridges;
- Introduction of mid piers for the anchorage of cables and to support the structures between suspension bridges Concept of San Francisco Oakland Bay bridge Western Segment.

Takings (two concepts) from two motorable bridges are briefed below.

4.1 Anchor (Mid) Pier

Referring to San Francisco Oakland Bay Bridge, the function of an anchor pier is very simple as its name hints that it hooks the anchors from both sides and supports the system between the two adjoining suspension spans. In the case of pedestrian suspension bridge cables on either side are anchored onto a fixed structure, i.e. mid piers or banks, while in motorable suspension bridge cables are anchored in deck, which is called as self-anchorage system. More importantly the introduction of anchor pier reduces the complicated continuous system to non-continuous one. Of two bridge systems bridging Oakland (East) and San Francisco (West), one linking to San Francisco i.e., West Bay Crossing is having two consecutive suspension bridges placed end to end with a separating anchor pier at the center.

The anchor pier has dual purpose that it reduces the continuous complicated to a system of simple individual bridges. The second part is to hold the anchor guys from either side of suspension bridges. The structural function of anchor pier is to resist the worst case of loading from both sides with unequal loading i.e. combination of static and dynamic loads (due to dead load and live load, wind load and others).

Referring to Kurushima Kaikyo Three Suspension Bridge, combination of serial three simple suspension bridges and cable anchoring in middle piers found to be an innovative solution for such wide river crossing, which is simple in structural system and cheaper.

The spanning system is similar to the above mentioned motorable Bridges (Figure 10), in which two adjacent 3-span bridges adopted with center pier to discontinue continuity. Hence, the proposed scheme is spanning over 1200m Mahakali River crossing in Dodhara & Chanadani VDCs, which will be managed with 3nos. of 3-span simple suspension bridges serially connected with a mid-pier anchor. The authority (Department of Roads) approved the new spanning system of three serially connected suspension bridges

(a) Kurushima Kaikyo: Mid anchorage system

(b) San Francisco Oakland Bay bridge: Mid anchorage system

Figure 8a & 8b: Side Spans connected with Mid Pier (https://commons.wikimedia.org/wiki/File:Kurushima_Kaikyo_Bridge-3edit.jpg & https://www.trekearth.com/gallery/North_America/Unid_States/West/California/San_Francisco/photo1549276.htm)

The whole system will have three consecutive suspension bridges separated by two center piers to hold the anchor cables. Each suspension bridge is with 270m main span, 80m side spans and 2nos. 35m end (approach) spans. The described example here above could be a solution to Dodhara Chandani Multiple Span Suspension Bridge with continuous system. The possible spanning system has been depicted in the sketch below (Figure 9) and details of span length given in Table 2.

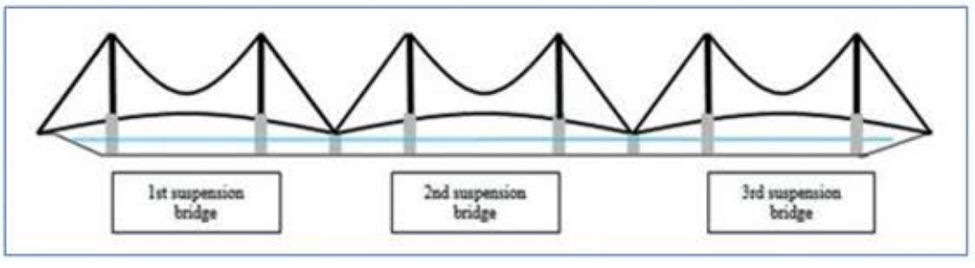
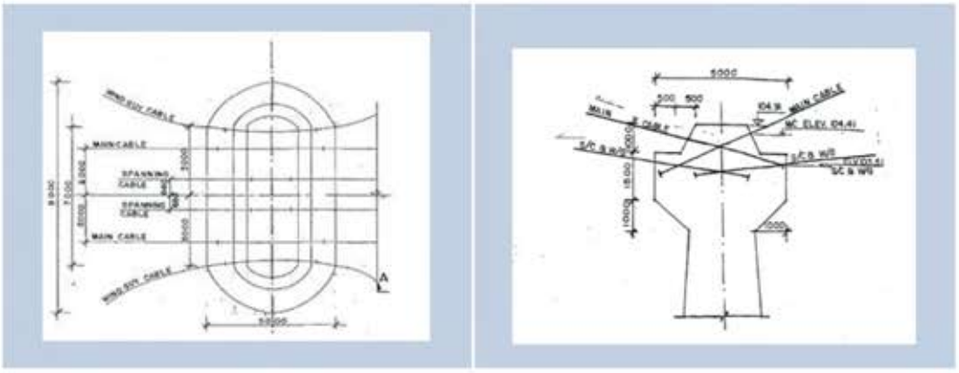


Figure 9: A schematic diagram of Three Suspension Bridges

Table 2: Details of span and lengths of Three Suspension Bridges (Department of Roads, 1999)

Bridge No.	Length	Centre span	Connecting
1st	385m	270m	Left Bank (Main Land, Nepal)
2nd	430m	270m	1st anchor pier
3rd	385m	270m	2nd anchor pier
Total	1200m		Right Bank (Dodhara & Chandani VDCs)

The plan & profile of anchor pier with the details of anchorage for side spans connection given in Figure 10a & 10b. Photograph of the mid anchor pier after the construction has been illustrated in Figure 10c. The concept of mid pier anchorage has been successfully applied.



(a) Plan of mid anchor pier

(b) Front view of mid anchor pier

(c) Photo of mid anchor pier with two side spans (after construction)

Figure 10a & 10b: Plan and Front Elevation of Anchor pier (Department of Roads, 2000), Figure 10c: Mid anchor pier after construction in 2005 (Arjun Dristi: https://photographylife.com/photo-spots)

5. Construction of Four Suspension Bridges

The detailed design of multi span pedestrian suspension bridge was completed based on the approved structural scheme of three suspension bridges. Later the detailed design was revised for four suspension bridges to cover 1400m span. In 2005 the construction was executed by Suspension Bridge Division at the cost of NRs. 95 Million (GBP 7 Million).

Figure 11: Photographs of Dhodhara Chandani Multi-Span Pedestrian Suspension Bridge (Arjun Dristi: https://photographylife.com/photo-spots)

Major features of the Dodhara Chanadani Multi span pedestrian Suspension Bridge are given in Table 3 and the bridge itself can be viewed in Figure 11.

Table 3: Main Features after Construction (DoLI,, 2015)

Main Features of Dhodhara Chandani Multi-Span Pedestrian Suspension Bridge			
Total length	1452.96 m	Width of pedestrian way	1.6m
Main Spans (4 nos.)	225.4m	Anchorage (nos.)	3
Towers (Nos.)	8	Tower height	32.72m

6. Conclusions

This paper has presented how design concepts from previous two motorable bridges were evaluated and adapted to develop the schematic design of Dodhara Chandani Pedestrian bridge in the context of rural Nepal, specifically in the selection of spanning system. This is an example of how engineer(s) could bring innovation and develop designs for unfamiliar situation.'

The structural spanning system is known to local engineers and contractor in terms of design, construction technology and operation. Structural design was possible for simple suspension bridge using the manual of Long Span Trail Bridge (LSTB), produced by Trail Bridge Section, Department of Local Roads (DoLI). Other benefits of this system are easy for operation and maintenance, and its whole life economic cost is low. This bridge is being listed with among other long bridges in the world (Collings, 2016).

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Resolving through Structural Forms: Examples including Mayadevi Temple

Kanhaiya Bhagat Koiri and Ghanashyam Paudyal

Sr. Engineer, Axiom Structures, London, 2Principal Engineer, WFS Corps, London

kbkoiri@hotmail.com, 2ghanashyam.paudyal@gpaonline.co.uk

Abstract

With the desire of innovative and complex structures around the globe, challenges in structural engineering to provide appropriate solution is ever growing. Experienced structural engineers innovate and apply different structural forms or their combination to meet the requirement. Selection of structural forms or their combinations desires an immense experience and sound understanding of structural knowledge and behaviour. This paper aims to describe how different structural forms can be applied if different challenging situations. Some examples practiced in Nepal are given along with one of the most important heritage structure in the world, the Mayadevi Temple located at the birth place of Lord Buddha.

1. Introduction

It has been a common global fashion to conceptualise structures uniquely and off the traditional track for aesthetic reasons. In addition, site conditions, surrounding constraints and even environmental challenges are also increasing simultaneously and push for a unique configuration. Ever since such complexities are growing, structural engineering is also facing increasing challenges to conceptualise, analyse and design of such structures. Meeting these challenges is difficult following the traditional tools and techniques, and hence a continuous evolution of new ideas, theories and practices are emerging.

Recent development in analytical tools with computerised automation in analysis and design is assisting engineers to have a courage and confidence to deal with such complex situations. Though the development of new and hybrid materials along with construction techniques are helping as well, choosing appropriate structural form has historically been to the core of the practice to face the challenges. Decision of structural form in difficult situations demands a perfect blend of the knowledge of theory, design tools and construction practices. For the reason, this is possibly the area where an immense experience and sound understanding of structural knowledge and behaviour is desired.

Several elegant structures are being designed and built everyday globally and various research and innovations are also progressing in daily basis. Along with the same line, this paper highlights the importance of structural forms, explain how choosing them appropriately helps to resolve difficult situations and provides some real project examples had been applied in Nepalese context where both the design and construction techniques are far behind compared to the developed nations. Ultimately the paper aims to establish playing with structural forms as an art of structural engineering.

2. Structural Forms

A combination of members connected to support external loads and to serve a useful function is called structure. The various structural systems that are used in construction can be classified as beams, columns, trusses, cables and arches, rigid frames, surface structures and space grid structures. A complete structure can incorporate any number of independent systems all of which act together to transfer load to the foundations and provide overall stability to the structure. Some of the common structural elements or systems used in construction are briefly described as below:

2.1 Rigid Frames

Rigid frames are often used in buildings and are composed of beams and columns. The loading on frame cause bending of its members. The strength of such frame is derived from the moment interaction between the beams and column.

2.2 Plane Trusses

When the span of a structure is large and use of beam becomes uneconomical or impractical a truss may be selected. Most often, it is economically feasible to use truss to cover span ranging from 9m to 120m.

2.3 Cables and arches

Cable and arches are other two forms of structures that are used for long span. Cables are often used in engineering structures for support and to transmit loads from one member to another. Cables are generally used to support bridges and building roofs. The arches resist external loads primarily in compression since it has reverse curvature to that of cable. Arches must be rigid to maintain its shape, and this results in secondary loading involving bending and shear, which must be considered in design. Arches are frequently used in bridge structure, dome roof and for openings in masonry walls.

2.4 Surface structure

A surface structure is made from material having very small thickness compared to its other dimension. Sometimes this material is very thin and flexible and can take form of a tent or air-inflated structure. In such cases material act as membrane that is subject to pure tension. Such a structure is also known as fabric structure. Surface structure may also be made of rigid material with suitable thickness to act as plate structure that derives their stiffness from their thickness. The strength and stiffness of such rigid plate structure can be significant increased by giving them suitable forms like folded plates, barrel vaults and domes.

2.5 Space Grid Structural System

A space grid structure is combination of linear elements so arranged that forces are transferred in a three-dimensional manner. In some cases, the constituent element may be two-dimensional. A space grid structure is usually arranged in an array of single, double, or multiple layers of intersecting members. The space grid structure can be formed either in a flat or a curved surface. The three-dimensional double layered space grid structure is commonly known as space frame or space truss depending on the type of bracing between the two layers and method of connecting the members (Figure 1). The double layer grids with inclined web elements pin jointed to top and bottom chord element are called space truss whereas the double layer grid structures with no inclined web elements, such as the grid with only horizontal chord and vertical webs connected to each other via rigid joints are known as space frames.

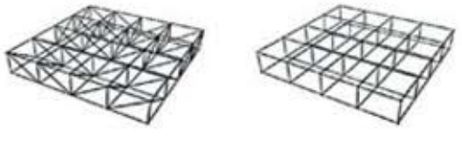

Figure 1: Basic Space Truss and Space frame configurations

Commercial space grid systems can generally be divided into three types: those that are assembled from discrete members running between node joints (often referred to as 'piece-small' systems or Nodular system), those that are assembled using continuous chords and those that are assembled from factory prefabricated modules called modular system. One of the Modular Space Frame System, developed by Leszer Kubik and his son Lslie Kubik, is shown in Figure 2, which is used to meet the structural challenges in Mayadevi Temple.

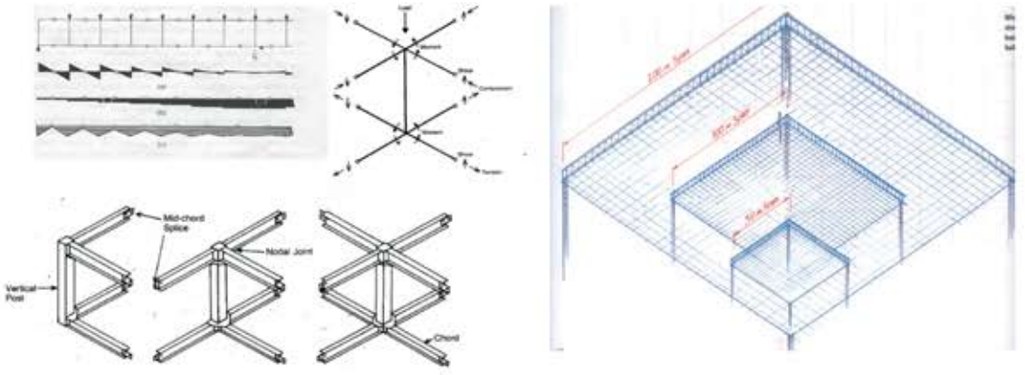

Figure 2: Standard Cubic Space Frame modules

3.Selection of structural forms

Selection of an appropriate structural system and structural forms for a specific project is a challenging decision-making process. The selection process is very wide and comprises every aspect that could affect the selection of structural system. The different criteria that need to be consider depends on owner needs, project location, project requirements, project constraints, code requirements, characteristics of structure like size, shape and span, aesthetic requirement, compatibility to surrounding environment, environmental factors like vulnerability to natural disaster such as earthquake and wind forces.

A clear understanding of the principles of structural behaviour and wider appreciation of non-structural matters such as cost, sustainability and aesthetics are essential to make selection of an effective and elegant structural system. The next section of paper discusses about the various projects in Nepal where different types of structural systems were chosen to satisfy project specific requirements.

4. Examples of structural systems

Different structures consist of different challenges and hence demand a unique structural solution, and hence, millions of structures around the globe have similar number of engineering way out. Nepal does not differ to this and hence multiple structural solutions to deal with peculiar situation have been applied in past. Leaving the practices all over the world, as examples, some of the projects the authors faced and worked in Nepal are demonstrated in this paper including a high profiled 'Reconstruction of Mayadevi Temple' project. These examples try to illustrate the peculiarity of individual sites and how playing with different structural forms give a unique and possibly the best solution for the specific challenges.

4.1 Radisson Hotel Backyard Shed

Radisson hotel had a unique requirement to have an additional roofed but open area to cater its overflow of parties and programmes being held on the Banquet hall at Ground floor. The shed had to cover back yard of the tall hotel block which had a greenery and artificial water fall of about three storeys high to the other side. It was desired that the shed is to be semi-transparent and design is to have absolute minimum obstructions at the floor, isolated from existing structures and most importantly, should not obstruct the view of water fall yet providing a shelter during rain and bright sun.

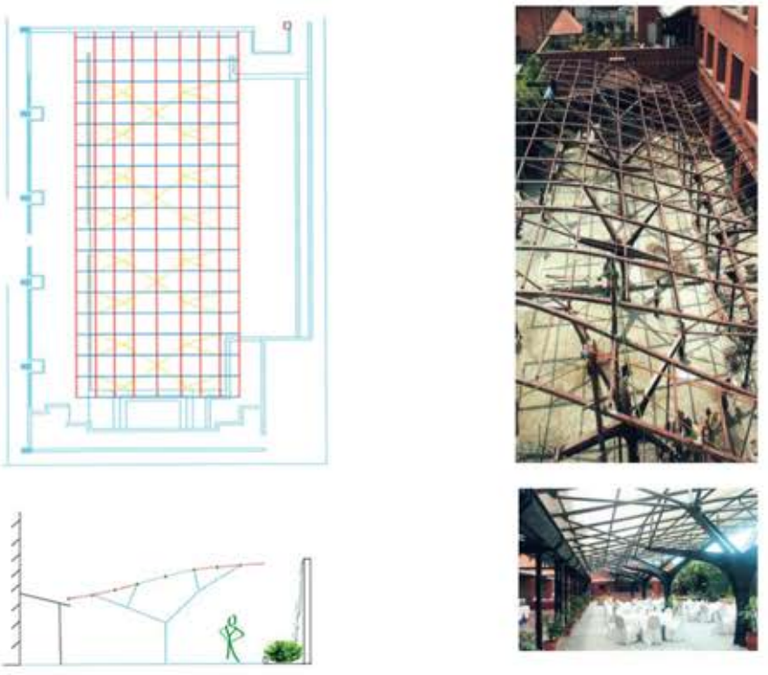

Figure 3: Radisson Backyard Shed in Tree Configuration

A solution to the desired shed was an isolated structure with four columns as trees with four major branches and four additional sub branches on each branch to support a curvilinear roof mat with translucent cladding. The columns were acting as vertical cantilever with moment bases.

4.2 Image Channel TV and communication tower

Image channel headquarter had a requirement of 57m tall TV and Microwave antenna tower to be constructed at their Lazimpat office complex. As the structure was to be at the heart of the city, tall and visible to public, it has to be elegant, unique and to be accommodated in a very small triangular footprint at the back yard. The normal angular option with traditional braced design was discarded due to its look. Smaller footprint, non-braced and yet with very restricted defection limit for MW antenna were the competing challenges. For the purpose, a slim triangular tower with tubular main columns, diagonally unbraced cantilevered vierendeel girder structural configuration was adopted to meet the requirement.

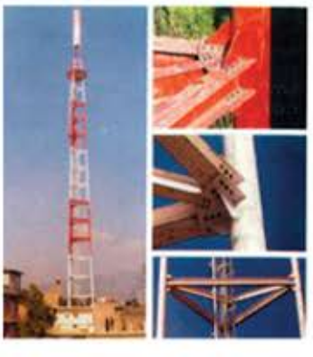

Figure 4: Image Channel TV tower, unbraced Vierendeel configuration

4.3 Kantipur TV Curved Bridge

Kantipur TV Headquarter had two office blocks constructed separately, nearly perpendicular to each other. Operationally these were to be connected for internal movement through a footpath on its third floor whereas minimum clearance, support condition and aesthetic requirement were the challenges. A horizontally and vertically curved bridge structure with nodal spaceframe having its support reaction converted to point loads to resist torsion was the solution provided.

Figure 5: Kantipur TV office complex curved bridge, nodal solution

5. Reconstruction of Mayadevi Temple

Reconstruction of Mayadevi Temple, which is at the birth place of Lord Buddha, is one of the most challenging archaeological site restorations in the history of Nepal. The temple is a UNESCO heritage, highly respected and regarded worldwide with original deposits of the age of more than 2500 years.

Historically, the temple is supposed to be back to the Buddha era. After nearly 200 years from the birth of Budha, Emperor Ashok visited the site and installed a marker stone with the help of his astrologers at the point where Buddha was born. In addition, he constructed a pillar called 'Ashok Stambha'. With several episodes of temple reconstruction in the history of couple of thousands of years, the marker stone was not visible and was supposed to be covered by the constructions. However, when the holy tree nearby destroyed the integrity of the temple, it was decided to remove the tree to safeguard the remaining ruins. Entire ruins were exposed, and at the same time, the marker stone remained as epic for hundreds of years was also found.

A temporary small temple besides the original temple was built and the statue of Mayadevi was transferred. Temporary shed was built to cover up the ruins from direct sun and water. After this, a permanent solution to rebuild the temple was started to be sought for which took more than a decade for different reasons.

Figure 6: Previous Mayadevi Temple, before and after excavation

5.1 The challenges

It was not a simple construction, the design not only has to acknowledge and respect the importance of the site which was being worshiped for more than 2500 years, but also for being one of the top-rated UNESCO world heritages, it needed to meet all the basic international requirements laid by UNESCO, as below:

- Non-Intrusive – similar look and size to the past, no vibration / concentrated / impact loadings
- Reversibility – entire structure including foundation
- Shelter – covered all ruins
- Visibility – visible ruins including Mayadevi Statue and Marker Stone
- Focus – focus was on Marker Stone and the Mayadevi Statue
- Access – to all important elements, including Marker Stone and Statue
- Worship – provision of worship from the first floor
- Authentic materials – Similar but not confusing one

Conceptual design challenges were enormous. The footprint of the structure was expected to be the same of previous temple whereas its foundation footprints were ruins and could not be used. It was expected that the all exposed ruins to be visible, accessible and covered whereas the height of the structure to be restricted to the previous one. The floor and roof level were expected as of previous, whereas the very important 'Mayadevi Statue' was to put at the same coordinate it was previously and should be accessible to view and worship from both ground floor and first floor. Apart from that, the ruins which were taller than the base level of Mayadevi Statue and very nearby to it was to be untouched and kept along with the statue, exactly as it used to be. Deciding the form and footprint of the structure was looked nearly impossible. On the top of the all, there was no any eminent and sufficient place around the previous temple where foundation could be built without disturbing / sitting on the ruins.

A next challenge was to select material in a way that this does not look too distinctive to the existing ruins, whereas the material similar to existing ruins could not be used as well as it may confuse future archaeologists. In addition, the entire construction material and method should be selected in a way that the entire structure, including its foundation, to be fully reversible. For this reason, the use of cement as well as concrete was not permitted at the site. Further, none of the structural elements could be dismantled in any day within the lifespan of the structure without any impact to the existing ruins were allowed, including piles if used.

In view of the design to build, the entire site was restricted for driving any trucks or vehicles. Operating any sort of motorised equipment were also not allowed within the site premises to avoid vibration disturbances to the ruins. Transportation, construction including boring and driving of piles, installation of structural elements etc. were to be done completely manually without any standard electrical tools and cranes. Due to the presence of ruins all over, no point or distributed load items during construction were allowed. A point load not more than 200kg in designated area was agreed as the maximum, which also had to be distributed using plates and logs at the application point. This also voided the possibility of using traditional Derricks for lifting and installation. These made the situation very difficult to conceptualise a suitable structural solution.

5.2 Attempts to identify a suitable solution

Several attempts from different professionals, organisations and institutions were made to find a solution that is buildable and spanning more than 10 years. These include the designs by the Design Committee formed by LDT, UNESCO team, Yoshinobu Kumagain, Dr. Mohmoud Bendkir, and by IOE Pulchowk team at last. Some of them are shown below.

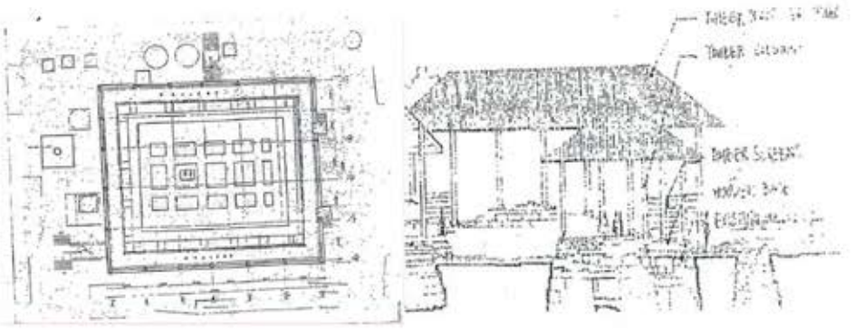

Figure 7: The Earliest Nepalese Team and Preliminary UNESCO Team Designs

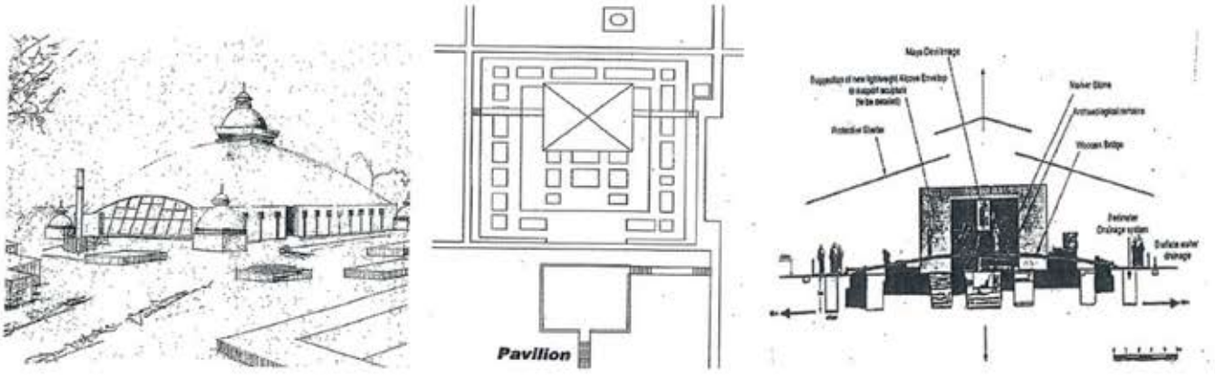

Figure 8: Bendakir and Kumagain Designs

The designs were judged by Japan Buddhist Federation, Buddhist Summit, Archaeological Department, Lumbini Development Trust and several committees and summits along the time including final judgement by UNESCO. All the designs were rejected stating that they did not meet one or more UNESCO guidelines.

5.3 The final structural solution meeting all requirements

Again, Lumbini Development Trust contracted IOE Consultancy Services to form a team of professionals and experts to develop a new design meeting necessary guideline. With couple of site visits followed by site survey, several discussions and merging the knowledge and experience, the team could come up with proposal that meets all requirements with some minor alternations, hoping it can convince UNESCO. The basic concept of proposal was as described below.

· Space for foundation – Isolated irregular natural trenches just outside of previous temple's wall footing, were being used to trap incoming water and pump out to lower water table of the area during flooding seasons. The trenches were filled back with stone pebbles so that the existing ground management was not disrupted.

Figure 9: Trenches utilized for foundation

· Foundation – Augured (manually by waterjet similar to boring for a tube well) and placed (manually with the help of Tripod) wooden piles (cannot be reverted but bio degradable)

· Pile Cap – Galvanized and Bituminous Painted Steel Grillage Foundation type pile cap, bolted to the head of rectangular wooden piles, galvanized to 610 g/m2, wasp primer and Coaltar Epoxy painted.

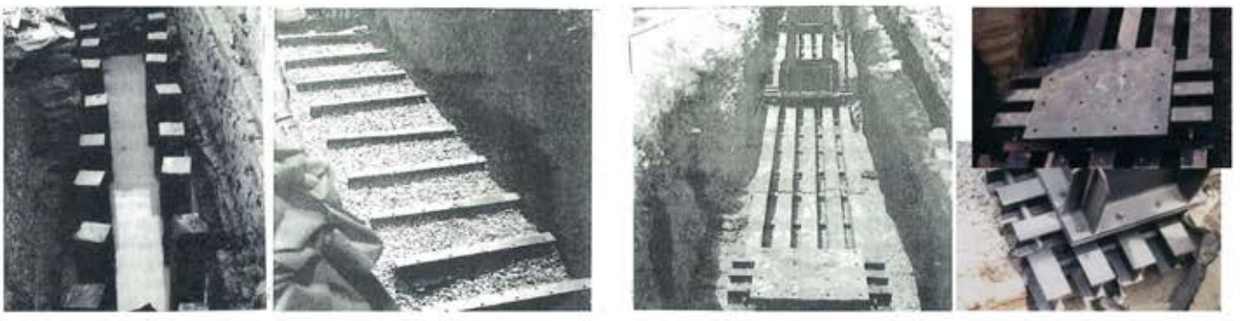

Figure 10: Wooden Pile Group, Pile cap, Pebble filling, Grillage and Cap plate to accept Base plate

· Column – Isolated built-up steel columns connected to pile caps with baseplates.

· Bracings – Tension bracings with Steel Bars and Turn Buckles

· Structural Configuration – Modified 'Cubic Structural System' with 'Beam and Basic Module' as basic concept.

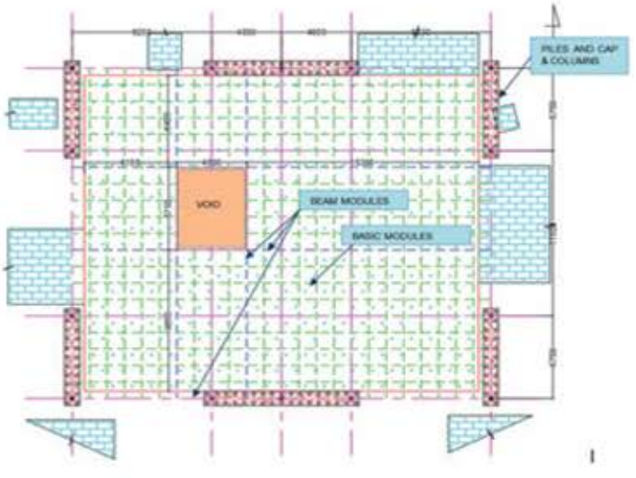

Figure 11: Structural Layout

· Floor structure – Modified Cubic Space Deck system separated in different segment and required Cut-outs using Beam Modules and Basic Modules of 1.2m structural depth

Figure 12: Beam Module Grids and General modules in between

· Transportation – By truck up to compound fence, manual afterward

Figure 13: Truck and Manual Transportation

· Erection – Manual positioning, Lifting by Chain Blocks and uplifting next module again sitting on the previous module.

Figure 14: Manual module erection, the next sitting on the previous

· Wall – Brick of different size compared to of existing ruins with Surkhi Mortar, plastered and painted to look as previous one

· Floor – Steel plate decking with Surkhi mix filling and Clay Tiles.

· Internal Platform – Walking deck suspended from the roof structure with clearance to the ruins

5.4 Technical shortcomings in design and construction, correction and load test

The design is peculiar and the only one of its type, therefore all the teams working for the project were pushing the boundaries they knew and experienced before. Despite of all care and efforts during design and construction, a problem of unexpected level of deflection was encountered when the installation was progressing.

A further look on the structural analysis, design, detailing and construction method revealed that the design using 'Shear Bolts' for the connection was the reason for slips in connections and resulting deflection of beam module. In general structure, possibility of such slip becomes negligible as there will be hardly couple of joints along the line of a single beam, whereas in this solution, there were up to 24 connections. Even a very small slip in each joint gave a cumulative result and hence the first-floor structure was deflecting beyond the expected limit. A mistake of over relying on 'Shear Bolts' and not applying 'Friction Grip Bolts' for Beam Modules was the basic reason for the deflection.

While reviewing the structure and planning to change the connections as friction grip bolts, it was realised that there could be some additional dead load on the structure. Ultimately, the structure was stiffened further to make it more resistant to additional loading and minimise the risk of deflection, and the connections were replaced with friction grip concept.

To ensure further confidence on the stiffness and hence deflection characteristics of structure, it was decided to undertake a load test with partial loading. The deflections recorded during and after load test were found as expected, and hence the structure was finally approved.

5.5 Similarity and alteration at last

Though the design was able to meet the all requirement laid by UNESCO as well as the desire of various stakeholders, there were some small alterations being proposed. These alterations, as briefed below, were explained to UNESCO and were agreed before starting the detail design.

· Footprint in Plan – It was not possible to have same plan dimension without sitting on the previoius wall location, and hence the proposed wall position was just outside the previous wall's foundation. The extreme dimension of temple was to be bigger by the thickness of wall. This made laying of wall and foundation possible giving insignificant changes that can be seen by general public, and hence agreed.

Figure 15: Comparative previous and current view of the Mayadevi Temple

· Height of the first floor roof – It was also impossible to be within the same first floor. Previously, it was an inaccessible single chunk of material whereas, the new requirement was to provide access to view the ruins and Marker Stone. A minimum structural depth as well as a clearance from the ruins to platform and a minimum head clearance for the public were also necessary. However we had to make it similar to previous, and hence, an alteration of additional height was proposed in such a way that the new high level ventilation was proposed to be at the similar level and fashion to previous pipe railings. Beyond the ventilation, the depth of the floor and new railing was being additional height. However the level of Mayadevi Statue was kept at the same coordinate as it was since long. This alteration was also accepted as it was unavoidable to achieve the desired outcome.

Figure 16: Internal view of new Mayadevi Temple

6. Conclusions

The discussion and illustration above show that, to facilitate the global fashion of conceptualising structures uniquely and off the traditional track for aesthetic reasons and to cope with varied site conditions, surrounding constraints and even environmental challenges, structural engineering is also developing further alongside the other engineering disciplines.

Despite the development in engineering tools and materials, choosing appropriate structural form has historically been to the core of the practice to face the challenges. However, deciding structural form and providing a 'fit to purpose' solution in difficult situations is an art of structural engineering which is possible by blending immense experience and sound understanding of structural knowledge and behaviour.

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Innovative technologies and sustainable practices in the energy sector to overcome energy crisis of Nepal

Ramhari Poudyal, Pavel Loskot, and Ranjan Parajuli

PhD Candidate, Swansea University, Swansea, UK

rhpoudyal@gmail.com

Abstract

The world is facing an enormous challenge to provide enough and sustainable energy to its burgeoning population. Energy is a fundamental asset for enabling socio-economic development and poverty reduction of any nation. The future role of digital technologies for generating, handling and communicating data has taken centre stage in energy discussions. Despite the huge water resources of 45,000 MW of Hydropower potential, 2100 MW of solar power and 3000 MW of wind power, Nepal is suffering from chaotic energy crisis for more than a decade. There is a big gap between supply and demand of electricity in one side, and on another side, there is a huge system loss and electricity theft up to 34 percent in some year according to the World Bank data.

This article gives a perspective of the energy crisis, supply demand scenarios of Nepal. It also explores how huge system losses and inefficiency in households, business and industry should be measured and suggests energy efficiency measures, smart grid, and conservation practices to save precious energy. How innovative technologies and sustainable practices would help to bridge the gap? Modern energy efficiency measures and conservation practices around the world will be highlighted as lessons learned from other countries. It also describes the importance of energy mix in the power system as Nepal is heavily dependent on Hydropower.

1.Introduction

The national debate about energy, like other issues, is highly politicised in Nepal. Political leaders should be serious to solve the rooted energy crisis. There are irresponsible actions to hand over hydropower projects without the feasibility study, or following the international bidding procedure to India and China (Poudyal, 2018), which require significant attention. In many nations, the future of energy is now at the top of the agenda. The demand for electrical power is growing three times as fast as the world's population. By 2030, global electricity demand could boost by two thirds according to the BP, Renewable Energy Review 2015 (BP,2015). However, Energy intensity of Nepal 139.144 KWh is very low as compared with the average of the world 3128.401KWh in 2014 (NEA, 2017). Moreover, energy landscape of Nepal is highly dominated by imported energy from neighbouring countries mainly from India (100 % petroleum products and Cooking Gas) and 50% Electricity and paying 28 billion Nepalese Rupees (NPR) to India every year for Electricity and 1.3 million tonnes of refined fuels every year with a cost of 109 billion for oil and 17 billions of rupees for LPG (NEA, 2017 and MOF, 2017). It is the main reason for the massive national trade deficit.

One of the -objectives of this article is to review the energy situation of Nepal with a focus on identifying mitigation measures of the energy crisis, which is supported by illustrations of the latest renewable energy technologies and future potential innovations at fulfilling the energy demands in a sustainable way.

1.1 Energy Scenario of Nepal

Nepal is blessed with a substantial theoretical hydropower potential of 83,000 MW, out of which 45,000 MW is considered to be techno-economically feasible (WECS, 2010). Nepal has about 6,000 rivers with the total length of about 45,000 km and the annual discharge of 174 billion m3of water. So far, only 961.2 MW have been connected to the peak load system (Table 2), which constitute about 2% of total energy supply (NEA, 2016). Only 58% of Nepalese citizens have direct access to the national grid, and other 9% rely on the off-grid renewable supplies (GoN, 2015). Since having access to the energy services plays an essential role in the social development, it is not surprising that the Human Development Index (HDI) of Nepal is only 0.548, ranking it as the 145th country among 188 countries in the world (UN, 2015). Connecting remote villages to the national grid would be very costly.

People in rural areas are isolated, scattered and often have no or inadequate access to public infrastructure and services. Half of these people live in the areas so remote that the nearest road and the national electricity grid is within few days of walking distance (Zahnd et al, 2006). Despite having more than a century-long history of electricity generation by the technical 6.6 million people in Nepal are still without electricity, and those who have electricity are experiencing long hours of load shedding during dry winter seasons as illustrated in Table 1 for the years between 2011 to 2017. Table 2 shows that the energy dependency on imported electricity is growing year by year.

Table 1: Electricity scenario of Nepal 2011-2017 (MOFN, 2016)

Description	FY 2011/12	FY 2012/13	FY 2013/14	FY 2014/15	FY 2015/16	FY 2015/16*	FY 2016/17
Production (MW)	705.57	746	746	829.2	855.9	829.2	961.2
Transmission line (KM)	1,987.4	1,987.4	1,987.4	2,848.9	3,006	2,848.9	3,204
Customer numbers	2,053,259	2,599,152	2,713,804	2,872,015	2,969,576	2,922,041	3,121,902
Distribution line (KM)	958,156	114,160.4	116,066.6	123,827.8	124,115	123,827.8	124,976
Available energy (GWh)	3,858.4	4,260.5	3,092.5	4,966.7	5,077.2	4,966.7	3,964.2
Peak demand (MW)	1,026	1,094	1,201	1,291.1	1,385	1,291.1	1,444.1
Demand supply Gap (MW)	320.4	348	455	461.9	529.1	461.9	482.9
India imports (GWh)	746.07	790.14	1,318.75	1,369.89	1,782.86	-	1,171.38

Another major factor contributing to the energy crisis is the lack of proper governance to overcome the widespread inefficiencies in the energy systems. For instance, the transmission and distribution (T&D) losses exceed 34% compared to the average losses of only 8% in the world while the highest levels are observed in the South Asian region (World Bank, 2015).

1.2 Causes of the energy crisis and its solution

The traditional national grid provides consistent power transmission during normal conditions. However, when natural calamities like earthquakes, storms, hurricanes, or security breaches threaten the national network, the ensuing power outages can be terrible and costly. After the devastation inflicted across the Caribbean by hurricanes Harvey, Irma, and Maria, millions of people were left without power for months. Similarly, the two devastating earthquakes in Nepal in 2015 damaged 14 hydropower dams, and the national grid lost more than 30% of its generating capacity. The flooding of 2017 in the southern part of Nepal caused the damages of 73 billion NPR (Nepalese rupees) and disrupted the electricity and telecommunication infrastructure which will cost an additional 242 million NPR (NPC, 2017).

Renewable energy advocates are calling for second thoughts of the region's distraught power systems. Rather than merely rebuilding grids that delivers mostly diesel generated electricity via damage-prone overhead power lines, renewable advocates argue that the island microgrids should leapfrog into the future by interconnecting hundreds or thousands of self-sufficient solar, small hydro, wind and biomass microgrids. Distributed Energy resources like solar, wind, the small hydro, the microgrid could also lessen the impact of natural calamities such as earthquake and flooding. Nepal's research and development activities on interconnecting microgrids could be of great value given the enormous opportunity to advance innovation in growing global energy markets. Energy system expansion is occurring in the power-hungry developing World. Nations such as India and China are advancing the United States and Europe by developing or procuring the latest technologies in power transmission, generation, and utilisation wherever possible.

Nepal could be a powerhouse to supply energy-hungry neighbours if it utilises the full potential by adopting new modern technologies and sustainable practices.

Furthermore, Nepal's geographical position, as well as its size and economic dependency, leave it vulnerable in times of geopolitical crisis. A respective tug-of-war between its bigger neighbours often sees Nepal caught in the crosshairs of a dispute that has not anything to do with it. Most of the projects have been won by India and China intentionally to occupy ground in strategic territory. Their lingering to start the project as enumerated in Table 2 and is also one of the biggest issues of developing significant hydropower in Nepal.

Table 2: Ongoing hydropower projects in Nepal funded by India and China (NEA, 2017)

Project	Power (MW)	Funder	Originated	Comments
Arun 3	900	India	November 2014	Project Started
Dudhkoshi 2	240	India	April 2015	Applied for the license.
Dudhkoshi 4	350	India	April 2015	Undecided.
Upper Karnali	900	India	September 2014	Land acquisition, compensation and Financial management problems.
Bheri 3 Storage	480	India	October 2012	Survey stage.
Western Seti	750	China	February 2012	PPA, Investment style not fixed yet.
Upper Marsyandi 2	600	India	2011	Equity and free electricity put on hold.
Upper Trisuli	102	China	May 2015	Applied for the license.
Pancheshwor Trishuli	6720	India	1995	DPR not yet read.

The recent flood of 2017, destroyed 43,433 houses in Terai region, displaced 21,000 families wiped out 8 billion worth of crops, and 242.3 million of energy infrastructure. Nepal needs NPRs 73 billion for flood recovery according to the report arranged by the National Planning Commission (NPC), the top body that frames the country's development plans and policies (Sharma, 2017). Floods are regular seasonal occurrences in Nepal and it also causes damages in downstream India. Nepal should meticulously analyse the social, economic and environmental impact before giving permission to make high dam hydropower project. John Vidal mentioned in the British News paper Observer entitled " China and India 'water grab' dams put ecology of Himalayas in danger" on 10 august 2013 more than 400 hydroelectric schemes are planned in the mountain region, which could be a disaster for the environment (Vidal, 2013)

The energy crises stem from the rising energy demands while the energy production from non-renewable resources is limited and diminishing. It has a direct adverse effect on the economy, and it is one of the significant problems the world is now facing (McLeish, 2006). In addition, Nepal Oil Corporation Limited is a state-owned trading enterprise of Nepal that imports, store and distributes various petroleum products. All the petroleum products and LPG for cooking consumed in Nepal are procured and imported from India. The nearest seaport from Nepal is Haldia (Kolkata) which is about 900 KM from the nearest Indo-Nepal boarder. Unfortunately, the present storage capacity of 71,622 KL is just enough for 15 days. This is the biggest bottleneck of energy crisis in Nepal as similar kind of storage capacity in other countries is about three months or more.

2. The Necessity of Energy Mix

Each energy sources have its advantages and disadvantages; however, hence harnessing energy mix is important to ensure a sustainable future. The traditional source of energy like oil, coal, and gas could run out in the next century unless alternative sources are found, and we start to adopt the energy mix. We could end up in a severe energy crisis. The world needs to find a sustainable way to produce more electricity in a cleaner, greener way if we do not want to suffer an energy crisis in the very near future (Poudyal, 2017). Besides, Nepal's energy mix is very inferior which is solely dependent on 99 % Hydropower.

Very sadly, Nepal has the highest system loss, up to 34% in some years according to the World Bank's data (World Ban, 2014). Interestingly, Nepal has the potential for generating 45,000 MW of Hydropower, including over 100 MW of micro hydropower, 3,000 MW of Wind, 1.1 million domestic biogas plants and 2,100 MW of solar energy (Poudyal, et al, 2017). Surrounded by that much renewable energy resources, ironically, Nepal is purchasing nearly 500 MW of electricity from India to balance our power supply and demand. That electricity is generated by dirty coal in Bihar of India which is not sustainable.

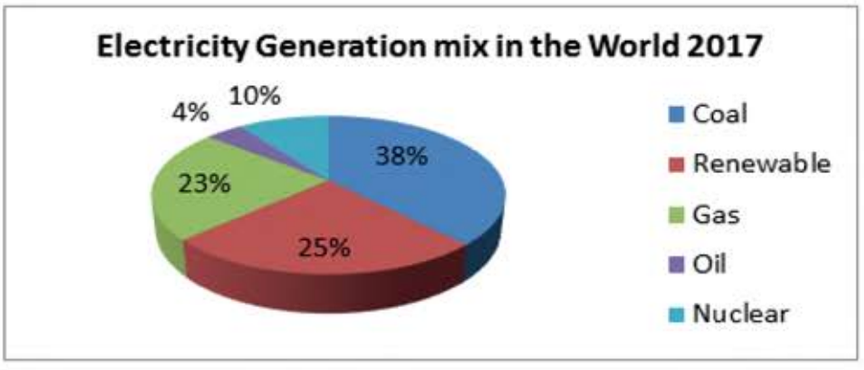

Figure 1 Electricity generation mix of the World in 2017 (IEA, 2017)

2.1 Energy Efficiency and Conservation

The UN Secretary – General's initiative Sustainable Energy for All mobilises global action to achieve universal access to modern energy services, double the global rate of improvement in energy efficiency, and double the share of renewable energy in the global energy mix by 2030. Conservation of natural resources is a crucial theme of sustainability. Although prices may increase overtimes. Nevertheless, a decrease in the extraction of virgin (natural) materials and the productive use of waste materials are essential societal goals, because these actions will (WBCSD (2017):

- Decrease negative impacts on natural habitats
- Lower the volume of wastes in landfills
- Reduce waste disposal costs, and
- Preserve undistributed land and minerals for future generations
- Lower net CO2 emission

Several actions should be considered and could be implemented to reduce energy consumption, emission and expenses. Using energy efficiently became a countrywide worry during the first half of 2008 as energy prices knock record highs. It has also been gaining in significance as a result of growing concern about the more efficient use of energy in the UK would save as much power as could be generated by six new nuclear reactors and shave £ 7.5 billion energy costs, the expert has calculated. The European Commission wants a binding target of improving energy efficiency by 30 per cent by 2030 compared with business as usual (European Commission, 2017). For example, in Nepal, the limestone-based cement industry has the highest rate of energy efficiency improvement margins compared to other sectors.

For the cement industry, the International Energy Agency (IEA) has categorised the four-main energy and emission reduction measures, resulting in a forecast to 2050. Energy efficiency (10 %), alternative fuel use and other fuel switching (24 %), clinker substitution (10 %) and carbon capture and storage (56 %) (IEA, 2009). All these areas offer interesting opportunities, though they are all characterised by various limitations to their implementation. Focusing on energy efficiency, the consumption reduction can be achieved through technological advancement (substituting or enhancing the existing ones) or with people (via a more conscious energy usage). However, some proponent of sustainability argues that resource consumption in all industries should decrease by a minimum factor of 4 or 10, and some organisations call for even more aggressive goals of factor 20 or 50 (WBCSD, 2017).

This weak energy supply situation can be rectified by proper energy infrastructure investments, sustainable energy, and energy efficiency practices. Nepal should consider developing a tough understanding of innovative technologies and sustainable practices in the international commercial realm. However, Nepal's investment in infrastructure is very negligible according to the World Bank estimate - infrastructure gap pegs investment needs at between 8 – 12 % of national income. Sadly, Nepal is investing just 0.3 per cent of its GDP for renewable energy infrastructure in comparison with 16% in Bhutan and 3.4% in India according to the World Development Indicator (World Bank, 2016).

2.2 The Necessity of Smart Grid and innovate technologies

Electricity networks are getting smarter, with digital infrastructure now accounting for over 10% of grid investment according to the recent data of IEA 2017 (IEA, 2017). An intelligent city uses an integrated approach to coordinate all essential services. It modernises digital and physical infrastructure to make delivery of these services more efficient, useful, innovative, and exciting. The stamina of a Smart City is "the smart grid" – another indefinable term, at least to the common people. The national grid is a combination of the electric power grid and advanced communications systems interconnected with and supported by a host of devices and sensors that mass and analyse data in real time. Through predictive analytics, machine learning, clean technology and, multidirectional communications, the grid will be used to optimise the efficiency of city services and operations, connect citizens, improve quality of life, and foster sustainability. Figure 3 shows an example of microgrid.

Figure 3 Example of Microgrid (Berkeley Lab, 2018)

3. The role of digital technologies in the energy sector

The future part of digital technologies for generating, handling and communicating data has taken middle stage in energy debate. Approximately $47 billion was spent in 2016 on software and infrastructure directed towards digitalisation of the electricity sector to facilitate more flexible network operation, demand management and integration of renewable resources. In the meantime, the gas and oil industry is scaling up its utilisation of digital technologies to improve the performance of its operations while keeping costs under control (IEA, 2017). In addition, in the same way, that omnipresent cloud, sensors and edge-of-grid computing, machine learning and big data have enabled the transformation of our electrical system, they will unlock sweeping changes to the rest of our energy, industrial sectors and transportation. Furthermore, development of the rail transport system, promotion of mass public transportation, construction of appropriate building standards and cluster homes and installations of industrial sites away from vulnerable areas are also some of the areas where we need to focus.

4.Conclusions

The use of renewable energy should be increased to deal with energy crisis and climate change. Due to technological innovations, the attraction toward wind and solar energy has grown remarkably in recent years all over the globe. The use of electric, hybrids and alternative-fuel vehicles should be given priority to cut down fossils fuel consumption and lower greenhouse gas emissions. Nepal should follow the energy mix trend, modern energy infrastructure development to its power system by learning from the world.

Load management for peak electricity demand savings through load-shifting and more focus on research and development (R&D) in the energy sector should be considered.

This article explored critical challenges in details, offering some relevant suggestions for consideration to reform and improve the energy sector of Nepal. It is recommended that the Government of Nepal should focus on transforming the energy sector by learning from the energy, science and innovative technologies and sustainable practices around the world. This paper also highlighted some of the international practices which can potentially serve as the corner stone for sustainable energy system in Nepal. It is expected that the outcomes of this research would serve as a useful reference for energy planning.

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Strategies for adoption of Building Information Modelling (BIM) in Nepal: Lessons Learned from the UK and Other Countries

Dr Ramesh Marasini

Associate Professor, Solent University, Southampton, UK

ramesh.marasini@solent.ac.uk

Abstract

Building Information Modelling (BIM) has been established as a means of improving efficiency and effectiveness in the construction project through collaboration and information exchange throughout the life cycle of the built facilities. With early adoption of BIM by the countries such as the USA, Singapore and the UK, it is becoming a common practice. Standards and codes of practices have been developed and best practice examples are readily available. Software developers are also working with the industry to provide interoperability amongst the specialist software solutions and to enable the collaboration amongst the stakeholders. Through the literature review of BIM adoption in the countries like the UK and the USA, this paper highlights the benefits, project management approach using BIM and the steps that should be followed to adopt and implement BIM to improve efficiencies in the Nepalese construction industry.

1.Introduction

Building Information Modelling (BIM) is increasingly being used in the construction industry around the world. The USA and the UK have taken the lead in its application through government strategies and initiatives and other countries are progressing with their adoption. As the clients require more certainty on cost and time in the completion of the projects, collaboration amongst the parties involved in the design, construction and operation of the buildings, infrastructure and other constructed facilities is crucial. BIM is now seen by some as the solution to long standing problems, highlighted by Latham (1994) and Egan (1998) reports, within the construction industry such as low productivity and poor collaboration. BIM Industry Task Group (2011), citing Construction Project Information Committee, defines "Building Information Modelling is digital representation of physical and functional characteristics of a facility creating a shared knowledge resource for information about it and forming a reliable basis for decisions during its life cycle, from earliest conception to demolition." The objective of BIM is to create a digital model of construction projects which draws on a range of data assembled collaboratively, before, during and after construction (NBS 2017). The digital model is used by the designers, contractors and clients (users) from concept, design, procurement, construction as well as operation and maintenance of the facilities to their demolition for efficient and effective decision making.

The National Planning Commission (2018) report on the progress of 21 national pride projects in Nepal shows that the majority of projects are not completed on time and within the budget; the average physical progress is reported around 80%. As the country is prioritising the development of the country through investments in new infrastructure projects as well as carrying out reconstruction of historic and iconic assets after the 2015 earthquake, the use of BIM will help to improve design, planning, construction and operation of these projects. BIM should be mandated in the procurement of public projects in Nepal to improve efficiency and reliability of their delivery and subsequently for the effective management of the assets using digital information.

2. Characteristics of BIM and maturity levels

In order to define the maturity levels of BIM use by the construction companies, 4 levels of BIM adoption have been identified (PAS 1192:2007+A2: 2016) from Level 0 to Level 3. The Level 0 is where BIM is used as a CAD tool to produce 2D drawings as traditional methods. The coordination is usually completed by hardcopy of paper drawings. Level 1 may use some 3D modelling and information is coordinated using information management protocols. Level 2 is the production of a 3D model of the building, where each element is modelled using parametric data. The model at this level will produce all 2D and 3D drawings, where if a change is made in one place, the model will update automatically everywhere. Level 3 is an ultimate stage which is described as 'fully interoperable' BIM. It is a fully integrated way of working. One model is created, shared and coordinated. All work by each discipline is completed on the same 'live model' requiring all project team to have the knowledge, skills and willingness to work in this way.

Traditionally, the processes of design and construction require communication to individual parties, which is very much fragmented, slow and inaccurate at times. The information is stored in different formats and places making it difficult to retrieve when needed. Figure 1 shows a basic concept of using a central digital BIM model which different stakeholders- designers, contractors, environmentalists, cost engineers, facility managers etc will interrogate and use to meet their information requirements throughout the lifecycle of the facility.

Figure 1: Development of BIM Model and Interaction of Stakeholders

As shown in Figure 1, the key elements of BIM include a 3D model and common data environment for information exchange (Level 2). The BIM model acts as a true representation of the building or a facility, therefore the architectural model developed initially is also used to carry out structural analysis and design, mechanical, electrical and services design as well as sustainability analysis, energy modelling, value engineering options and more. The design models and information from architects, structural engineers, M&E engineers, contractors, subcontractors and suppliers are integrated into a digital model to create a federated BIM model (Level 2 BIM) or integrated model (Level 3 BIM), which becomes a central resource for the project teams. At the construction stage, all as built information is included in the model with Operation and Maintenance information. Creating an integrated digital model enables those who interact with it to optimize their actions, resulting in a greater whole life value for the asset (NBS, 2016). To achieve the Integrated Project Delivery standard, a 'live model' (BIM Level 3) needs to be used, which will be edited and used by all stakeholders according to assigned rights and software interoperability is essential.

A Common Data Environment (CDE) is required for collaboration and sharing information. COBie (Construction Operations Building information exchange) is a spreadsheet-based environment which can be used by the client or any stakeholder without the need of any specific IT ability and manual transfer of information from other sources of information such as a programme and other documents. This is used at level 2 BIM. For the fully integrated model, Industry Foundation Classes (IFC) are used, which puts much more emphasis on software. The Architecture, Engineering and Construction (AEC) industry is still suffering from interoperability issues as the IFC development continues.

It is important to note that BIM is not a software, instead it is a process of managing information using digital technologies so that information is readily available and shared amongst the project participants. Based on the type of information integrated in the BIM model, additional dimensions are commonly used to describe the BIM model. For example, a 4D model has the 3D model connected with programme information, the 5D model has cost information, the 6D model consist of asset information and so on.

3. Drivers and Challenges of BIM

Researchers and practitioners in the field of BIM have highlighted significant benefits of BIM. The key benefits, as highlighted by Eastman et al. (2008) include early identification design errors, clash detection, accuracy of cost estimates and energy performance, and resolution of safety problems thereby achieving buildability and effective performance of the facilities. The clients will benefit from the cost savings and the supply chain will be able to reduce errors and improve efficiency and hence increase profitability in the projects. Better quality of information at all stages of the project to make decisions for the clients.

Although the use of BIM brings efficiency in the whole life cycle of the facilities, the early adopters are designers as BIM is successfully used in design stages. Designers use the 3D model to demonstrate to their clients different building options and scenarios, showing how a design change could affect the whole programme and budget. The model is used for value engineering, design review and clash detection. BIM also supports for sustainable building design, which can produce the necessary information to make an informed decision on the best possible design solution. The data suggests that organisations share 3D CAD models between different parties differently where collaborative working is meant to be achieved. There is a very low usage of COBie data. Industry Foundation Classes (IFC) based common data environment are being used by the BIM-software and will be used more commonly in future.

The real advantage in the use of a BIM model is realised at facilities management i.e. post project completion. In most of the projects that have implemented BIM, the client has been the main driving force for demanding its use. The main contractors have successfully used BIM in the projects using design and build procurement. The UK government industrial strategy aims to develop capabilities that are available in manufacturing sector such as the use of BIM to realise 'design for manufacture and assembly' and 'lean construction' to raise bar for product and process efficiencies (Cabinet Office, 2011). The strategy aspires to move BIM to Smart Communities and Future cities. Currently BIM mainly focuses on modelling a single asset, its value will be further enhanced when multiple assets in the built environment are modelled and managed or the assets are integrated to provide public services.

Despite many contributions it has to offer, BIM has also presented some challenges for many organisations. The software interoperability remains one of the key challenges as well as initial capital costs (hardware and software), training and keeping up with the developments in the use of BIM. As BIM is a change process, there will be resistance in its use. For the policy makers and managers of construction businesses, it is important to understand the ways of overcoming resistance to change. It will be challenging to promote the use of BIM in Nepal as it needs to be supported by a programme of training and education as well as long term investment and commitment from the government and large construction companies. Furthermore, the technical capabilities of the companies providing IT infrastructure need to be considered.

4. Project Management approach using BIM

The project management approach for BIM projects is different from the traditional project management methods. A shift in project management approach is required and significant effort and time is required in the early stages. Early involvement of contractors as well the facility managers is inevitable. BIM Overlay to the RIBA (Royal Institute of British Architects) Outline Plan of Work (RIBA, 2013) highlights how to adopt the traditional RIBA outline plan to BIM projects. The procurement and contract should support the use of BIM. Different suits of contracts such as New Engineering Contracts (NEC), standard form of contract for project partnering (PPC2000) and Joint Contracts Tribunal (JCT) have produced contractual provisions to use with BIM to ensure all parties are bound to share data. However, the International Federation of Consulting Engineers (FIDIC conditions of contracts do not yet have included the provisions for BIM.

Key elements of the BIM projects are: Employers Information Requirements (EIR), BIM execution plan (BEP), Master Information Delivery Plan (MIDP) and Asset Information Requirements (AIR). The models developed during design and construction stages constitute a Project Information Model (PIM) and after the handover of the project the model used will be Asset Information Model (AIP). Details of these can be found in RICS (2017). The analysis of BIM projects in the UK suggest that BIM is mainly used in the design stages and then it is not used during construction. In addition, it does not go far enough to include Asset Information Requirements (AIR) for the facility management. Project management using BIM requires the roles such as BIM manager, BIM champion etc. An experienced BIM manager is required to use BIM successfully in projects. This will lead to the demand for the BIM trained professionals to drive the initiative. The use of BIM in projects will require collaborative working which will means a change in the culture of traditional project management practices.

5. Key considerations to promote the use of BIM

The process of adopting BIM should be viewed in two ways: first, establishment of government priorities, development of policies and mandate to include in the project implementation. Second, organisation level adoption- how to manage the BIM adoption within the company processes. These are best described by pull or push (BIM Industry Task Group, 2011). Pull is mainly demand side, in the case of BIM, government making it mandatory to use in projects and creating an enabling environment and clearly defining what is required. Push occurs when industry (supply chain) sees the opportunities for efficiency improvement, minimise the risks and start using the BIM in their practices to develop their capabilities.

5.1 Government Pull

The study of BIM adoption processes in countries such as the USA, the UK and Singapore, as highlighted by Smith (2014), have shown that the use of BIM has been promoted by the governments showing leadership and developing enabling environments through mandates i.e. making the use of BIM as a requirement in public projects. Smith (2014) further suggests the other key strategies adopted include: national and global BIM standards, legal protocols for liabilities, BIM certification, education and training and establishing the business case. The government pull has been a major driver for the adoption of BIM in construction. The adoption and success of the digital initiatives such as BIM depends on the context of the country and strategies followed by the stakeholders. Succar and Kassem (2015) present 5 different adoption models that can be used to decide to structure the development of new ones or assess their ongoing BIM adoption efforts. It should be noted that the adoption is about accepting or rejecting the technology or change. To be effective and realise the benefits quickly, the rate of diffusion, which describes how innovation spreads through the population (Straub, 2009), is very crucial. The government effort should be in both adoption and diffusion of the technology such as BIM. The rate of diffusion of BIM within the industry depends on the rate of acceptance by the large companies and their supply chain. As benefits of BIM are well established, the role of government would be to encourage its use both in public and private projects.

The adoption of BIM must be considered as a 'comprehensive change management programme', not a reactive short-term initiative. The progress should be gradual (World Economic Forum 2-18). Kassem and Succar (2017) highlight the important steps of adoption of BIM which include: establishment of task group, development of BIM policy framework, engagement with stakeholders, development of a roadmap, development of pilot programmes and develop supporting documents. This is further discussed in section 6.

5.2 Industry Push

In the UK, large companies have a well-established practice of using BIM. NBS (2017) shows that the number of companies, which are 'aware and currently using BIM', has increased in the UK from 13% in 2013 to 62% in 2017. Similarly, 48% of small companies have used BIM as compared to 74% of medium sized companies and 74% of large companies. The companies which use BIM have improved their business processes to drive efficiency. However, the large companies have not been very effective to drive BIM through the supply chain. On the contrary, this has been successful in the US.

Table 1: Factors to be considered for BIM adoption (Paine and Marasini, 2013)

Decision Variables	Considerations
BIM Readiness	Review the company's position and capabilities, and ask, is the business ready and set up to be successful with BIM.
Client Demand	What clients, will benefit from BIM, can the company market its new capabilities?
Government Strategy	Government construction mandate and sustainability agenda.
Staff training	Capital required to train staff, will be one of the first start-up costs. The willingness of staff to embrace a different way of working and their tolerance for change.
Funding and Cash-Flow	Business investment is needed in the form of purchasing numerous software, marketing BIM capability, training, hardware. All needing time and resource to carry out.
Legal implications	Business Insurances may need to be revised, contracts, ownership of models legalities.
Technology Capabilities	Understanding software and its functionalities and interoperability issues with software.
Supply chain BIM Competency	How will the business integrate its supply chain? How will it evaluate which consultants to use on its BIM projects?

The leaders in the industry should support smaller businesses as it has been done in the US. Looking at the Architecture, Engineering and Construction companies view point, the factors that should be considered in the adoption of BIM are presented in Table 1, which include the BIM readiness, client demand and supply chain competencies.

6. Strategies to Implement BIM in Nepal

Published literature in Nepal and review of major project documents based on the internet search and visits to the projects by the author, the use of BIM and its use in Nepal is in very early stages. Some of the papers in the use of BIM in Nepal highlight the use of software such as Revit (AutoDesk) or ArchiCAD (Graphisoft) in developing 3D models. The applications include automatic creation of plan, elevation and section drawings, which can be considered as BIM level 1. Real benefits of BIM are realised from Level 2. Further research to establish the extent of use of BIM should be investigated. There seems to be lack of studies in systematic approaches to BIM in Nepal.

Figure 2: Steps of adoption of BIM at government level

In order to encourage wide adoption of BIM, the government and construction companies must work together. There is a need for developing standards to use BIM in construction projects. The government authorities should take initiative to pull for its use facilitating case studies and examples how BIM should be used in the construction projects. Based on the journey of adopting BIM by the USA, the UK and Singapore, the steps the government of Nepal should follow are presented in Figure 2 and discussed in the following sections.

6.1 Establishment of Task Group and develop policy documents

Government initiatives and policies are essential to stimulate the use of innovative practices such as the BIM which will ensure faster diffusion of technology and hence leading to widespread use. For example: in the USA, GSA was established, BIM task group was established in 2011 in the UK and Digital Building Platform [Platform Digitales Bauen] was established in Germany in 2015. European Union has established EU Task group too. Singapore promoted BIM through the Building & Construction Authority and published the BIM roadmap in 2010; since 2015, BIM e-submissions have been mandated.

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6.2 Engagement with stakeholders

For any initiative to be successful, buy in from the stakeholders is required. The stakeholders include government organisations, designers, contractors, planners, professional organisations and educational establishments. The involvement could be ensured through workshops and seminars.

6.3 Development of roadmap

The road map includes strategies, key dates, milestones and responsibilities of the stakeholders. The plan should include 5 to 10 years of co-ordinated activities. Policy development, developments of guidelines, education and training should be prioritised.

6.4 Development of pilot projects /case studies

Case studies and pilot projects are effective to develop awareness and demonstrate the use of BIM processes and the benefits realised through the implementation in the context of country and cultural practices. In the context of Nepal, the professionals and companies can learn from the case studies and practices developed in the countries like the UK, the USA and Singapore.

In Nepalese context, high level and complex design works are carried out by the foreign consultants. There is a diversity of practice and the use of BIM in projects will be at variable level. Development of pilot projects will not only demonstrate how to use BIM but also support developing confidence in the supply chain. Since the BIM models provide as-built information at handover and the information required at operational stages, the management of facilities (assets) can be performed effectively saving time and resources.

6.5 Education and Training

Investment in education and training is needed to develop awareness of the BIM and to develop the skilled professionals required to drive the processes and to bring culture change. The top-down model is used in the UK where the government has driven the adoption of BIM as a mandatory requirement in publicly procured projects. BIM should be part of the curriculum in Engineering and Technology related degrees. Initiatives to embed BIM in the curriculum should be a first step towards the adoption of BIM. NBS (2016) BIM survey in the UK has noted that even after five years of government pull, many firms still feel they lack the skills and knowledge they need to implement BIM methods.

Looking at the curriculum of Civil engineering and Construction Management degrees run by the leading Institutions in Nepal such as the Institute of Engineering are yet to include BIM concepts. The curriculum should integrate BIM to guide the students from project initiation to handover to use so that there will be graduates entering the industry with required skills. BIM training programmes should be a priority to upskill the existing workforce.

6.6 Investment in software and computer infrastructure

The investment in software and hardware, including servers, cloud storage etc, are required to implement BIM by the construction sector. The areas of BIM investment also include training, standardisation of information management processes as well as development of 3D product data libraries etc. New job roles such as BIM co-ordinators will be required to manage the integration of information and facilitate the BIM processes. The government should incentivise companies to use BIM through contractual requirements. The literature and case studies published indicate that the investment in BIM can be recovered very quickly, from a year to three years, as this leads in organisational learning resulting in productivity gain due to the use of new collaboration processes, elimination of design errors in early stages and subsequently bringing efficiency in the use of resources in projects.

6.7 Development of collaborative working culture and assurance of long term commitment

Adoption of BIM requires a cultural change. In the construction industry, there is a culture of resistance to change and risk aversion. For BIM to achieve its full potential, changes in the organisation and work practices are required. All the stakeholders such as clients, consultants, contractors, manufacturers and facility managers need to collaborate digitally, which requires skills development by all involved in the use of BIM. Clients, who would be pulling the use of BIM should be aware of BIM so that they will be proactive from the early stages of the project. The government should review and monitor the progress in the use of BIM whilst maintaining the long-term commitment for its use.

7. Conclusions

BIM adoption should be a priority by the Government of Nepal and the construction organisations in the design, construction and management of constructed facilities. The benefits of BIM have been demonstrated by the use of BIM in countries like the UK, Singapore and the USA. Nepal can learn from these countries and use BIM to improve productivity through collaborative working and information exchange throughout the life cycle of built facilities. The journey for the adoption of BIM should be commenced with the establishment of a Government Task Group.

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Bus Priority: A Tool to Improve Bus Services in Kathmandu

Dr Birendra Shrestha

Principal Transport Modeller, United Kingdom

Birendra.Shrestha@tfl.gov.uk

1. Introduction

Buses are the predominant form of public transport in most towns and cities in many countries, including the UK. With their large carrying capacity, buses make effective use of limited road space, and can therefore make a substantial contribution to reducing traffic congestion. However, buses themselves are often affected by congestion, leading to a decrease in speed and an increase in bus travel time variability and service irregularity. Providing priority to buses plays an important role to protect bus services from the effects of traffic congestion and to improve route frequencies, speeds and reliability (IHT, 1997). There are a number of bus priority measures that can be considered to assist buses. These measures vary in scale and impact from a simple exemption from a turn at a junction prohibited to other traffic, advanced bus priority at traffic signals using an application of Intelligent Transport systems (ITS).

2. Bus priority types

Giving priority to buses is an important measure to protect bus services from the effects of traffic congestion and to improve their speed and reliability. The appropriateness of a measure depends upon the aim and of a scheme and the constraints surrounding the scheme. The aim could be to reduce delays to buses arising from traffic congestion and thus save bus operating costs, passengers' travel-time costs and bus-fleet requirement. Similarly, availability of roadspace and the cost of a priority measure could constrain implementation of a measure. These constraints depend on the way of giving priority to buses. These various ways of giving priority to buses could be categorised as physical measures, signal measures and integrated measures.

2.1 Physical measures

In this type of measures, physical changes are made to the road geometry or usage to assist buses. With-flow lanes, contra-flow lanes, bus only streets, busways and turning exemption at a junction are examples of physical measures. With-flow bus lanes are the most common form of bus priority measure. Keeping Buses Moving (DETR, 1997), describes with-flow lanes as a reserved traffic lane for the use of buses, usually on the nearside (Figure 1). A with-flow bus lane enables buses to bypass traffic queues, usually approaching traffic signals. This will often mean substantial time savings to buses and their passengers, offset by some additional delay to vehicles which have been overtaken.

A contra-flow bus lane is a lane where buses are allowed to travel against the main direction of traffic flow in a one-way street. This operation enables buses to avoid unnecessary diversions, to maintain route patterns and to gain better access to business and shopping areas. These contra-flow bus lanes are usually introduced in area-wide one way traffic systems, where the effect is to create a two-way road with 'buses only' allowed in one direction, and all types of vehicles in the other direction.

Figure 1: A bus lane in operation in London

A bus-only street is a section of road for the use of buses only. It may be a section of road enabling buses to take a more direct route or a "pedestrianised" street in a town centre where buses are exempt from a prohibition on other vehicles (DETR, 1997). Such a street enables buses to maintain route patterns in areas where traffic flow patterns have been changed and to gain close access to business and shopping areas where there is no access to other vehicles. This access to the main attractions can be advantageous in encouraging the use of buses.

Busways are substantial corridors or networks of bus-only sections of road constructed specifically for the exclusive use of buses. Busways are designed to segregate buses from general traffic that protect them from congestion. A variant of such measure, automatically guided or tracked busways could be an option where land availability is limited.

At junctions, turning exemption is a simple type of bus priority measure which allows buses to make a turn that is prohibited to other traffic. This is an inexpensive measure giving a considerable advantage to buses by allowing them to take a shorter route than other traffic. The exemptions can be used to enter into a contra-flow bus lane or a bus only street.

2.2 Signal measures

At signalised junctions, there is scope for many forms of bus priority options (Hounsell and Landles, 1995). The most straightforward form of priority at traffic signals is to bias signal timings so that the approach having higher bus flow gets more effective green time than it would have done otherwise. The other approaches then share the remaining part of the cycle time. This form of priority could be implemented by optimising signal timings to minimise delay to people at the junction, rather than vehicles, as is traditionally undertaken. The benefits of such priority are generally limited as the buses are not individually targeted and green time allocated for the bus approach could be wasted.

A more efficient priority can be given by triggering the priority only after detecting a bus in the traffic stream. This is achieved by making the traffic signal responsive to the arrival of the bus by using some sort of detection technique available. In this method, buses are given priority at traffic signals by utilising selective vehicle detection (SVD) techniques. In this system, buses fitted with some form of electronic device are detected by different techniques before reaching the junction. The detection techniques could range from a simple loop and transponder to advanced Global Positioning System (GPS) based Automatic Vehicle Location (AVL) system (Shrestha, 2003). Once a bus is detected, a priority is given by altering the traffic signal timing in its favour. Priority to buses may be given by extending the green time until the clearance of the bus or by recalling the next green time to give green to the bus more quickly. A typical bus priority at traffic signals as implemented in London is shown in Figure 2.

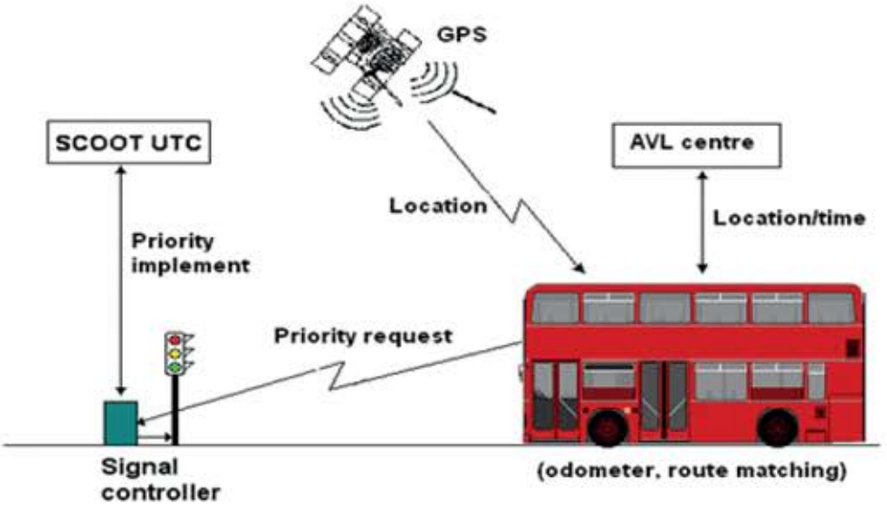

Figure 2: A typical bus priority at traffic signals (Hounsell and Shrestha, 2012)

Bus priority with selective vehicle detection is an effective system in giving priority to all detected buses. This system gives a good base for bus priority by minimising the bus delay at traffic signals and hence reducing the journey time of the buses and journey time. A SVD priority system providing the same level of priority to all buses may not often be that effective in maintaining service punctuality. One of the options for making buses more punctual and regular is by giving them priority according to their need to maintain their punctuality or regularity. This could be achieved by giving different levels of priority to buses according to their need for the priority.

Differential priority is a common term used to describe the strategy where different levels of priority are given to buses at traffic signals according to their need. Differential priority can allow a higher level of priority to be given to some buses (e.g. those which are late) and a lower level or no priority to others. Although this type of strategy can help make buses more punctual and reduce passenger waiting time, it gives lower journey time savings compared to the strategy giving priority to all buses. Clearly passengers waiting for a bus gain from improved punctuality, whilst those on board benefit from reduced journey times.

In London, Transport for London's (TfL) has implemented GPS (Global Positioning System) based AVL (Automatic Vehicle Location) system known as iBus to give differential priority to buses. In this system, detector locations configured in the on-bus computer (known as "virtual detectors") to detect buses on the approaches of traffic signals to request priority (TfL, 2006).

2.3 Integrated measures

In signalised junctions, the segregated type of priority such as with-flow bus lanes may be combined with the signalling measures. Pre-signal is one such measure in which the flow of traffic is held just upstream a junction by using a pre-signal. The bus lane running up to the downstream of a pre-signal enables buses to by-pass the traffic queue held upstream of the pre-signal (Figure 3).

Figure 3: A bus by-passes a queue of traffic at a pre-signalled junction

3. Kathmandu Context

Apart from being the capital city, Kathmandu is the most populated city in Nepal. Being a main hub for businesses, education, health and foreign travel, the population of Kathmandu is ever increasing. This has led Kathmandu Valley through a phase of massive urbanization, with the population going up by a million within few years.

Along with the growing population, the vehicle ownership is also increasing. Particularly, the car ownership is increasing as a result of relative improvement in the buying power of middle class families and relatively lower cost of the cars. Apart from that, the poor quality of public transport facility in the Valley has also contributed to this cause. As a result, there is a considerable increase in traffic in Kathmandu's roads. Serious traffic congestion with frequent standstill of traffic for extended periods in Kathmandu Valley's roads is a daily routine (Figure 4). This has significant costs in terms of lost time, wastage of fuel and air pollution.

Figure 4: Buses in the mix of Kathmandu's congested traffic (Source: Setopati.com)

In such situation, one of the most viable options is to improve public transport facility in Kathmandu. This could reduce the reliant on the private transport and the pressure on the road network. Currently, most of the public transport is operated by individual transport owner forming a group. Such privately run system has serious shortcomings of timeliness, coordination, overcrowding and comfort. There is no guaranteed scheduled departures of the services, no connectivity to other services and tendency to board as many passengers as possible. The entire motive is to collect as much revenue as possible from individual service as it is personal business. In addition, due to the cost involved, there is no provision to improve accessibility of public transport for children, elderly and disabled people in such services.

Realising the shortcomings of public transport facility in Kathmandu Valley, there has been recent effort in making services better. As a positive sign, the local authorities in Kathmandu Valley are trying to improve urban transport in Kathmandu by introducing better quality buses and running in time and use of pre-paid cards. Sajha Yatayat, which is a cooperative organisation with local authority as shareholders, runs 9 routes in Kathmandu Valley. To give some respite to elderly and disable people, some of the buses running by the organisation are low floor buses (Figure 5).

Figure 5: Low floor urban buses in Kathmandu (Source: Sajha Yatayat.com)

Even though such initiative is in the right direction, more needs to be done to improve operations of such buses by reducing the impact of congestion in their journey time. In this context, providing priority to buses could alleviate them from such impact of congestion. With improved journey time, buses could run on time, build on trust of the passengers and increase patronage. In long term, reliable public transport could work as a catalysis for reducing the demand for private vehicles and encourage modal shift from car to bus in congested city areas of Kathmandu Valley. The increased patronage in the public transport would facilitate investment in more accessible public transport along with all benefits of public transport stated at the beginning of this paper.

Due to the infrastructure and space constraints, it not possible to implement a standard bus priority scheme in Kathmandu. Hence a suitability assessment of various bus priority measures is given in Table 1.

Table 1: Suitability of bus priority measures for Kathmandu in short term

Priority measure	Suitability	Reason
Bus lanes	Yes	Locations where there is roadspace available for such measure
Turn exemption at junctions	Yes	Simple and inexpensive measure which could be very effective if properly designed
Bus priority at traffic signals	No	Virtually no working computer controlled traffic signals Technologically complicated
Integrated measures	No	Virtually no working computer controlled traffic signals

Table 1 shows that some of the physical measures that could be implemented at some locations in short term are:

- improving junction to allow buses make turn which is banned for other traffic
- introduction of bus lane and bus only street

When implementing any such measures, the locations need to be thoroughly studied before making a choice of a bus priority measure and its design.

4. Conclusions

This paper has described various ways of assisting buses in the urban environment to reduce the impact of traffic congestion. This includes a simple turning preference at a junction to advanced bus priority at traffic signals. The appropriateness of these measures depends on the aim of a scheme and the constraints (physical and economic).

In Kathmandu's context, even though an advanced type of bus priority measures is not be possible to implement at this stage in Kathmandu. However, some other physical measures at junction and road section are possible to implement to alleviate buses from growing traffic congestion. As it will not be possible to implement a typical type of measure at all locations, all the schemes need to be thoroughly studied before making a choice of a bus priority measure and its design. Implementation such bus priority measures would be a tool to improve bus services in Kathmandu.

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Sustainable Building Design and Construction Approach in Nepal

Bidur Sharma Chapagain

Principal Structural Engineer, Harley Haddow Engineering Consultancy, Edinburgh Scotland

bbleosharma@yahoo.com

1.Introduction

The overall aim of sustainable development is 'to enable all people throughout the world to satisfy their basic needs and enjoy a better quality of life, without compromising the quality of life of future generation' (Defra 2005, p.6). The principles of sustainable development are based on the following main three pillars (Figure 1): Environmental protection, Economic development and Social development.

Figure 1: Triple bottom line diagram illustrating the principles of sustainable development.

In other words, sustainable development usually relies on a balance between economic, social and environmental issues. The concept of sustainability is broadly discussed in various stages in the past. The World Commission on Environment & Development (WCED), more commonly known as the Brundtland Commission, was formed by Javier Pérez de Céullar, former secretory of General of the United Nations, in December 1983. The purpose of this commission was to unite countries in the pursuit of sustainable development. According to chair of the Commission, Gro Harlem Brundtland, the 'environment' is where we live, and 'development' is what we all do in attempting to improve our lot within that abode. Environment and development both are inseparable from each other. The Brundtland Commission published it's report, 'Our Future', in 1987 (United Nations, 1987) and coined the phrase 'Sustainable development'.

Sustainable development is the kind of development that meets the needs of the present without compromising the ability of future generations to meet their own needs (United Nations 1987). One of the United Nations programs working towards a better urban future is known as a UN-Habitat- their mission is to promote socially and environmentally sustainable human settlements and achieve adequate shelter for all. It is estimated that 6 out of every 10 people in the world will reside in big cities by 2030. However, cities are already facing unprecedented demographic, environmental, socio-economical and spatial challenges. In many places around the world, people are facing a number of serious issues - lack of liveable housing, inadequate and out-dated water supply system, sanitation, transportation, energy supply, escalating unemployment, poverty, threat of safety & crime, health & pollution. UN-Habitat was mandated by the UN General Assembly in 1978 to address the issues of human settlements throughout the world, focusing on building a brighter future for villages, towns, and cities of all sizes. The UN successfully organised a conference on Housing and Sustainable Urban Development – Habitat III in October 2016. This document plays a great role on decision making for the development of integrated modern cities. The role by the UN towards sustainable development is helping to bring experts, experienced practitioners and researchers together to contribute their experiences and knowledge for planning, designing and building sustainable, green and smart cities around the world. The missions put forwarded by the UN hope to tackle natural global climate change issues, such as, deforestation, flooding, landslide, erosion, ice-melting etc. One of the UN goals should be to find a solution to the rapid growth of the building industry which effects the surrounding environment.

The best way to make building construction more environmentally friendly, economically and socially inhabitable is to adopt sustainable building design frameworks and principles.

Sustainable building design is more about the adoptability, resilience, comfort and user understanding than it is about assumed design consideration factors. Although, a lot of research has been carried out on sustainable, green and smart buildings, it is always important to ensure that we are using good practice in our construction industry with consideration to the built environment. To achieve sustainable buildings we should consider the following four principles (Anger and Fennes, 2013):

- Principal A1 - Environmental sustainability – within limits
- Principal A2 - Socio-economic sustainability – 'development'
- Principal A3 – Intergenerational stewardship
- Principal A4 – Complex system

New approaches in sustainable building design create an opportunity for architects, engineers, builders, property management organisations and researchers to explore new construction products and develop new skills and services in the building construction business. The implementation of sustainable building design process and construction methods help all parties involved in various construction phases, and end users to understand the values of environmental impacts left on our planet due to the traditional construction methods. It is commonly said that, on average, we spend over 90% of our live inside buildings and travelling between them. Globally, 40-60% of total national energy is consumed by buildings for the use of heating, lighting, ventilating and servicing. Based on the amount of energy consumption, it can be considered that buildings are the largest single human made contributor to global warming and hence climate change.

The building design is a complex process as it depends on geographical conditions, construction materials and methods, project value and scheduled time. Considerations for the design of new buildings should be based on three main principles of sustainable development - environmental impact, social values and economic issues. Though, it is a daunting task, considerations and incorporation of design parameters taken in building design can play a key role for achieving a sustainable building.

2. Basic Principles for Sustainable Building Design and Measuring Tools

In order to achieve a sustainable building throughout its life span, basic design principles, and building performance assessment tools should be considered at each stage of building's life.

2.1 Sustainable Building Design Principles

Sustainable building design process is based on the following principles:
- Whole life planning (which includes life- cycle assessment, whole-life costing) & design for deconstruction,
- Understand the needs and context,
- Managing the process well
- Recognise the benefits of innovation
- Work collaboratively.

Sustainable principles alone however, do not set a project brief. They drive the project to meet the client's aims and help set sustainability goals from design to construction stages and from completion to operation (service) stages. Once the principles of how to design and construct a sustainable building are understood, to achieve its full potential, the building users must be able to operate and live in the building in the way that was intended. Study proves that handing over a sustainable building to an occupant who is unfamiliar with the way the building works and who has not been informed about the criteria of building performance during early design stages, will lead to the building underperforming. All occupants may not be familiar with the concept of sustainable building design using innovative technologies. Sometimes, an information gap also exists between architect, design teams, builders and users that reduce the level of building performance throughout its life cycle.

2.2 Soft Landing Framework

To achieve the targeted goal of sustainable building before completion of the project and during and after its life cycle, powerful tools should be applied into practice. For example, UK is adopting useful guidance called "soft landings framework" - an open-source procedure brought by BSRIA (Building Services Research and Information Association) & UBT (Useable Buildings Trust) - with the aim of providing a unified vehicle for engaging with outcomes throughout the process of briefing design and finally delivery. Soft landings framework is based on the following five stages:

- Stage 1: Inception & briefing
- Stage 2: Design development and review (including specification and construction)
- Stage 3: Pre-handover
- Stage 4: Initial aftercare
- Stage 5: Aftercare in years 1 to 3 after handover.

2.3 Assessment Methodologies and Tools

There are various assessment methodologies and tools being used across the developed countries to collect and compare the building performance indicators after handover to occupants or users. Widely used examples of methods in the form of standards of practice in sustainable building development are:

1. Whole- building evaluation methods
2. Discrete impact evaluation methods
3. International, regional and national standards
4. Regulatory compliance tools
5. Design tools
6. Post- occupancy tools and process

Following methods have been widely adopted in practice:

- BREEAM (Building Research Establishment Environmental Assessment Methodology) (UK, other national and international use relating to building and community levels)

- LEED (Leadership in Energy and Environmental Design (US and international use based on the US version, relating to building and community levels)

- DGNB (Deutsche Gesellschaft für Nachhaltiges Baune) (Germany, Austria and Denmark based standards for the environmental evaluation of buildings)

- Greenstar (Australian Green Star Rating system)

- NABERS (National Australian Built Environment Rating Scheme) (Australia)

- Pearl Building Rating System (Estidama- Abu Dhabi Urban Planning Council)

- MB (The Swedish Miljöbyggnad system)

- HQE (The French based system)

- Other methods, tools and standards relating to specific countries.

These kinds of tools are used to evaluate the established energy and environmental standards but each tool has its own weighting percentage against the set goal for energy, indoor environment, water, materials, waste, site, construction phase, transport, economy, innovation and others relating to sustainable building design.

3. Current Challenges for Sustainable Building Construction in Nepal

Nepal, a landlocked country depends on the strength of neighbouring and other countries to fulfil the demand for construction materials, heavy equipment, fuel, technologies, work force and more. Apart from these dependencies, Nepal has slow progressing political and constitutional settlement, which remain key issues for not achieving the targeted goal towards planning and developing of new buildings, in and out of the main cities. Some of the current national issues and problems residing in the construction industry in Nepal can be summarised below.

1. Community settlement and social values
2. Political influences
3. Lack in implementation of ethical codes of conducts
4. Shortage of skilled and nonskilled workforces, technology and material supply
5. Lack in public awareness
6. Lack of capital due to poverty
7. Lack in implementation of legal and management policy
8 Terrain constraints

In the last decade, Nepal has several national pride infrastructure projects in various sectors under construction. The majority of them have not been completed yet on time and within allocated project cost. The unsuccessful projects are due to the aforementioned challenging factors residing in Nepal. Few examples of uncompleted projects include: Melanchi Water Supply Projects (MWSP), Kathmandu-Tarai Fast Track, West Seti Hydroelectric Project and Tamakoshi Hydro Project.

4. Importance of Sustainable Building Design and Construction Approach in Nepal

Buildings are a fundamental part of daily life, where we live, work, entertain and play almost 80% of our living existence, and this trend is increasing rapidly due to the increasing facilities of new technologies. A high rate of people from remote villages, whose family members are working abroad, are settling in towns/cities or municipalities and capitals to seek better living standard and good schooling for their children. What that means is that demand for new building space will expand dramatically each year. On the other hand, increasing levels of sophistication in new advanced technology, communication and connectivity, smart sustainable buildings will become an integral part of everyone's lifestyle. This is a big opportunity and a challenge for Nepalese construction industry to work towards meeting the housing requirements of people considering smart, green and sustainable building design.

Evidence shows that Nepal is being actively involved in achieving 17 sustainable development goals (SDG) set by UNGA in September 2014. One of the 17 goals, goal 11, emphasises on sustainable development in construction industry. Nepal Planning Commission has published National (Preliminary) report in 2015 under heading of Sustainable Development Goals 2016-2030. In the report, SDG11 proposes to make cities and human settlements inclusive, safe, resilient and sustainable. It is estimated that 7% of Nepal's urban population lives in squatter settlements and only 30% of houses are safe to live in. The proposed targets for 2030 include reducing multidimensional poverty, doubling the proportion of households living in safe houses, increasing the road density to five km/m2, making 50% of roads safer (for driving) and creating new satellite cities (taken from NPC report.

Completion of reconstruction work after devastated earthquake in 2015 and progress toward gaining the targeted SDGs are important task to be implemented by the current government. These tasks can create a new platform in the country to consider and implement the principles of the sustainable building design for future generations. Nepalese government should give first priority on sustainable building design and construction methods while selecting and planning new towns/cities in coming days. Many Nepalese people are still living in remote villages with difficult topography, as a result, there are always key challenges to provide basic facilities like schools, hospitals, drinking water and road access. Furthermore, land sliding, flooding, river erosion and human made transport accident are taking life of innocent people each year in Nepal. Such a situation should not be allowed contributing to loss of life in Nepal. The government must take initiative towards meeting these necessities, whilst, considering sustainable development in the sector of buildings and other infrastructures.

The following basic building physics and behavioural principles must be adopted for sustainable building design:

- Understanding of three main principles of sustainable development (it helps to design sustainable buildings)
- Shelter & security
- Behaviour, lifestyle & adaptation
- Orientation, solar gain & shading (natural behaviour)
- Heating, cooling & insulation (to adopt with outside atmosphere)
- Natural ventilation
- Daylighting

The above mentioned key factors are more related to building structural behaviour in relation to the proposed building location. The following sustainable management principles are also equally important for Nepal and should be used at every stage of design and construction if a building is to be sustainable: Water & sanitation, Solid waste, Transport for connectivity, Energy supply, Resources (natural) and Maintenance. The following additional issues need to be considered in local and governmental level of Nepal to keep new residential development zones sustainable prior to selection of the construction sites:

- Uncontrolled and illegal land business (Land regulation should be powerful tool)
- Illegal earth work/mining
- Road connectivity in remote villages without the study of environmental impact assessment
- High level of political influences (selection of project and tendering stage)
- Illegally approving building design and final construction work
- Uncontrolled rate of migration from villages to cities/towns.

Prior to sustainable buildings projects commencing in Nepal, it would be prudent to adopt the already proven and widely used design principles and assessment tools. Such as, UK based BREEM and US based LEED could be adopted. Based on the internationally adopted design guidance and assessment tools for sustainable buildings, Nepal also needs to develop its own design codes, guidance and tools to meet the requirement of the country in the near future.

5. Conclusions

Future buildings need to take into account the challenges and opportunities brought about by technological, environmental and societal changes. To meet the requirements created by these changes, we should consider sustainable building design approaches in the future, which can be in the form of green building or smart building or people-friendly development. Sustainable building design approach is based on the above mentioned three principles of sustainable development. It means, the purpose of sustainable building design approach is an integral part of sustainable development, which is becoming a goal of all countries to tackle global warming and its consequences in the world. Like other countries, societies across Nepal will require comfort, safety and will need to adopt to demographic change in coming days.
Sustainable building design principles should be considered at the early stages of the designing process to incorporate all factors and components, which may reflect at construction stage and whole life cycle of building. Sustainable building designs help to minimise the use of scarce resources, the need of unsustainable transport, flooding and pollution, and helps to reduce cost of energy, sewerage, water supply and waste management. After the earthquake event in 2015, it is more essential to introduce sustainable building across Nepal. This approach can be taken as an opportunity for introducing a new revolution in the Nepalese construction industry that considers the demand of new generations and the necessity of environmental protection. All concerned parties and government authorities should be responsible and accountable to prompt this mission and to achieve the targeted goal aimed in SDGs 2015. On the other hand, the Nepal government has put forwarded the slogan as “Prosperous Nepal, Happy Nepali”.
Sustainable building design and construction approach can be fundamental base to fulfil the national slogan.

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Sustainable Drainage System (SuDS) for Surface water Management

Shailendra Kajee Shrestha

Senior Drainage & Highway Engineer, Invvu Construction Consultants, UK

skshrestha701@gmail.com

1.Introduction

Sustainable Drainage System (SuDS) is a method of managing the surface water by using a sequence of techniques that includes collection, storage, infiltration and cleansing before it releases slowly back to the watercourse to reinstates to pre-development flow rates. Sustainable Drainage System (SuDS) aims to reduce the volume of water discharged to the receiving water body by encouraging the infiltration of water into the ground, and by providing water storage within the site (source) to attenuate the peak discharge and decreasing flow rates to the watercourses. The use of SuDS can improve the quality of surface water and control the water pollution.

Sustainability is a concept that deals with mankind's impact, through the infrastructural development, on environment. Today's environmental problems like flooding, air pollution, water pollution etc. are largely a consequence of the unsustainable use of natural resources and the mismanagement of runoff from rainfall and waste products. The impact of urbanisation on the water environment is very crucial. The hard surface of a new development such as roofs and paved surfaces generates 99% of storm water that do not percolate into the ground as effectively as the greenfield sites (area of forest land or agriculture land or undeveloped land). Figures 1a and 1b below illustrate how the new development significantly increases the surface runoff to receiving water bodies.

Traditionally the highways, paved areas and the roof water are discharged to the combined drainage system that eventually discharges to the treatment plants. However, more recent developments in the United Kingdom are served separately by the surface water drainage system that finally discharges into the watercourse. Though separate system reduces the load to water treatment plants and prevents polluting of watercourse from overwhelming foul water, it is no more sustainable. The increased run-off due to the urbanisation not only increases the peak flow and runoff volume impacting the water hydrology of receiving watercourse leading to the risk of flooding, but also cause water pollution in the downstream catchment.

2. Effect of urbanisation in surface runoff hydrology

2.1 Pre-development

The Figure 1a shows the pre-development scenario of greenfield site. During the storm event the rainwater travels slowly and infiltrates into the ground (aquifer) and interflows. Some rainwater evaporates and very little overland flows (surface flow) that discharge to the watercourse. The interflow helps to avoid the peak flow discharge into the watercourse, such that the downstream catchments are less affected from the surface water flooding even in high intensity of rainfall. It preserves the natural water balance and significantly reduces the surface runoff.

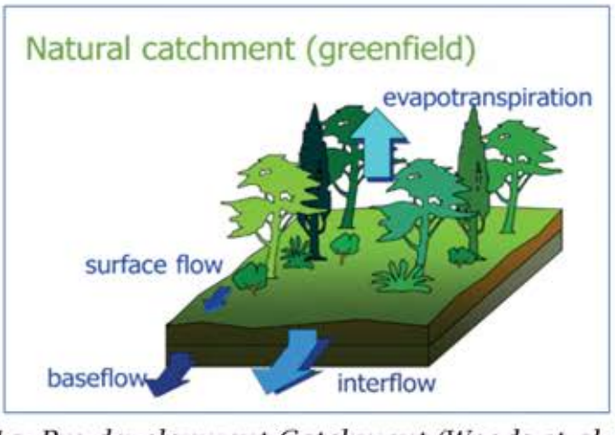

Figure 1a: Pre-development Catchment (Woods et al, 2015)

2.2 Post development

Figure 1b is the post development scenario comprising impervious catchment areas. The impervious areas generate a significant amount of surface runoff from the new development. It is known that the surface runoff from the developed area is 70-80% higher than the undeveloped catchment.

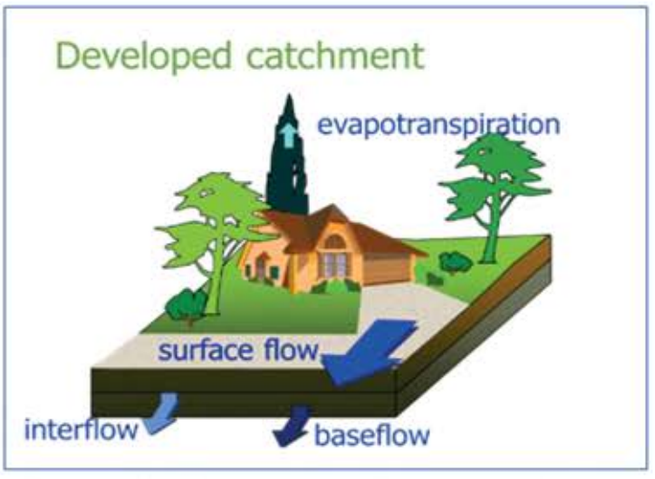

Figure 1b: Post-development Catchment (Woods et al, 2015)

The changes of the catchment areas from greenfield to impervious will increase the peak flow and lower the interflow due to the time of storm water entry into the collection system being faster than the runoff from the greenfield sites.

The conventional method of pipes and concrete channels allows the storm water to drain faster and reach the downstream areas much quicker than the water from an undeveloped catchment area. This can result increased flows in receiving watercourse which could cause flood risk, damage to resident, highway, erosion and landslides of downstream catchment. In the UK, Flood Risk Assessment is carried out in pre-planning stage to avoid the any consequence of flooding elsewhere due to the new development.

3. The Principle of SuDS

The principle of SuDS technique is to control the problem associated with the surface runoff from the development as near to the source as possible by mimicking the natural processes with the characteristics of storage, infiltration, slow conveyance, filtering out any unwanted pollutants, allowing sediments to settle out by controlling the water flow and some volume reduction. The aim is to restore the ground and surface water flow patterns that existed before the development took place. Sustainable drainage system categorised mainly into four groups in term of benefits as described in CIRIA C753 SuDS manual (Figure 2). This includes managing water quantity (flood risk etc), water quality and providing amenity and biodiversity.

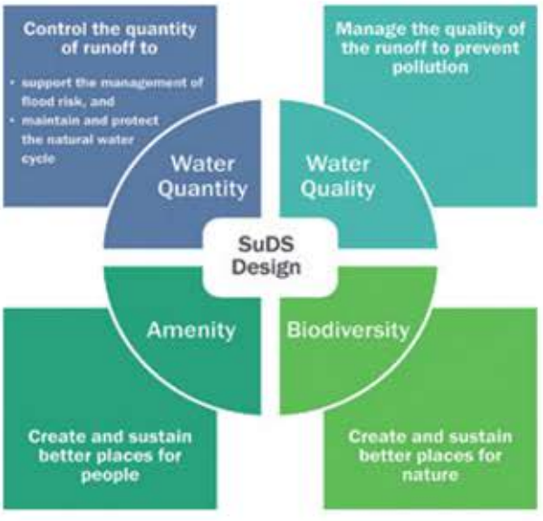

Figure 2: SuDS Design Principle (Woods et al, 2015)

There are the various SuDS options available in infrastructural developments. The infiltration, attenuation, green roofs and the water harvesting techniques are placed within the new development areas, which control the quantity of flow volume and reduce the pick flow to the downstream watercourse and the drainage system. These techniques are to protect the downstream peoples and the assets from the possibility of increased flood risk due to the new development. This system recharges the ground water, protect the natural flow regimes in rivers, lakes and streams.

The use of swale, filter strip, detention pond, retention pond, wetland, pervious pavement helps to removal of hydrocarbons, silts, debris, organic matters, heavy metals from the runoff through a variety of physical and biological treatment process that result to improve the quality of water. Besides that, swale and wetlands generally deliver the treatment and hydraulic control alongside amenity and biodiversity benefits. SuDS components provide the opportunities to create an attractive green and blue (water) corridors' in developments for connecting people and the environment, which would improve quality of life and create better communities. Some SuDS components are explained below.

3.1 Infiltration system

The surface runoff can be discharged into the ground via several infiltration techniques which can contribute to reducing the runoff rates and the flow volumes while supporting base flow and groundwater recharge process. These include soakaways, infiltration trenches, infiltration blankets and infiltration basins.

3.2 Pervious Pavement

Pervious pavement is a load bearing construction surfaced with material or paving blocks with gaps that allow surface water to permeate the underlying construction. The storm water is stored and conveyed through the sub-base construction. The pervious pavements provide attenuation, infiltration as well as some water treatment to the surface runoff. These are more popular in car park areas, new residential development and the business premises.

3.3 Swales/Detention basins/Wetland

The swale can utilise the common green space alongside roads and highways or any other open space. It gives a low flow velocity, slowing the water and giving pollutants in the flow a chance to settle out. Swales avoid the need for expensive roadside kerbs and gullies and have low operational and maintenance cost. Detention Basins are designed to attenuate the peak runoff primarily during an extreme storm events and to let the sediment settle out. The Wetland Pond provides valuable amenity and ecology benefits.

Figure 3: Components of SuDS (Environment Agency, 2018)

Retention pond is used to retain the significant amount of water all the time and pond can become an attractive local amenity as well as an effective filter for nutrients, trace metals and organic matter.

3.4 Underground attenuation storage tank

The system is used to store surface water temporarily before it discharges into the ground, watercourse and drainage system. There are several storages techniques, but more popular systems are: Geocellular (crates) storage system, Oversize concrete pipes, Oversize plastic pipes and precast or in situ concrete box culvert sections and tanks (including flat-packed concrete panels). This option is used in the development areas near to the site as source control. The surface water is controlled by the installation of hydro-break or orifice in the tank before the water discharge into the watercourse or drainage system to protect the downstream catchment areas from the flooding.

3.5 Runoff Hydrograph and Attenuation Storage

The Figure 4 below shows the hydrographs comparing different scenarios in pre-development, post-development with and without flow attenuation system. The green hydrograph in Figure 4 shows the surface runoff in pre-development scenario in the Greenfield areas. The blue colour hydrograph in the Figure shows increased peak flow rate following the development due to increase of impermeable areas. This shows the development causes major impact on receiving water body which could result downstream catchment flooding. The impact can be minimised by utilising the SuDS such as attenuation tanks, ponds or swales. The red colour hydrograph shows the effect of attenuation in the drainage system. With attenuation and flow control system the surface water is released slowly to the downstream system without increasing the peak runoff rate.

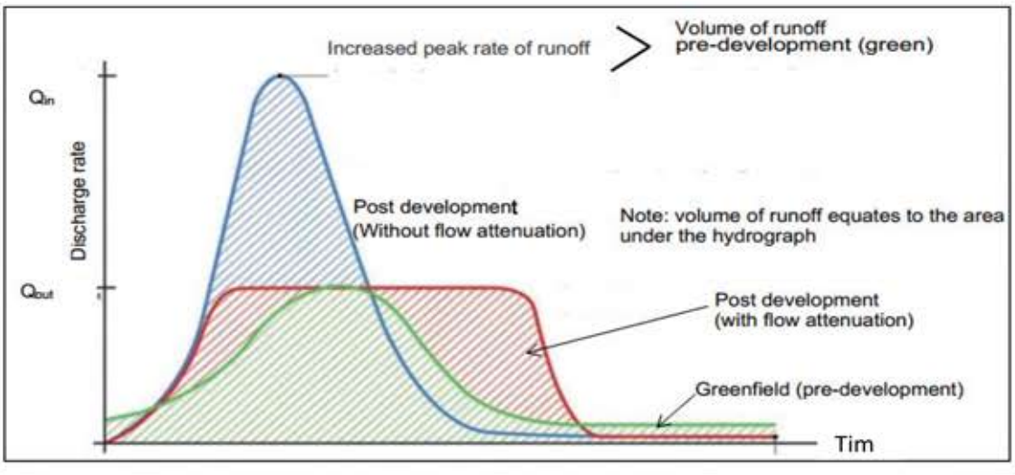

Figure 4: Runoff hydrographs (Woods et al, 2015)

The discharge rate of pre-development is determined by hydraulic analysis using MicroDrainage software or Wallingford procedure. The post development discharge rate can be controlled to the pre-development rate using hydro-brake orifice, weir etc in attenuation tank that stores the excess surface runoff and released slowly to the receiving waterbody.

4. Design Concept and Typical Application of SuDS in the UK

Figure 6 above shows typical example of using various SuDS in a new development .Usually, in the UK the drainage system is designed not to flood the site for up to 1 in 30years storm events, and to retain exceedance flood water within the site for up to 1 in 100years storm events plus the climate change allowances (typically 40% for residential and 30% for industrial development).

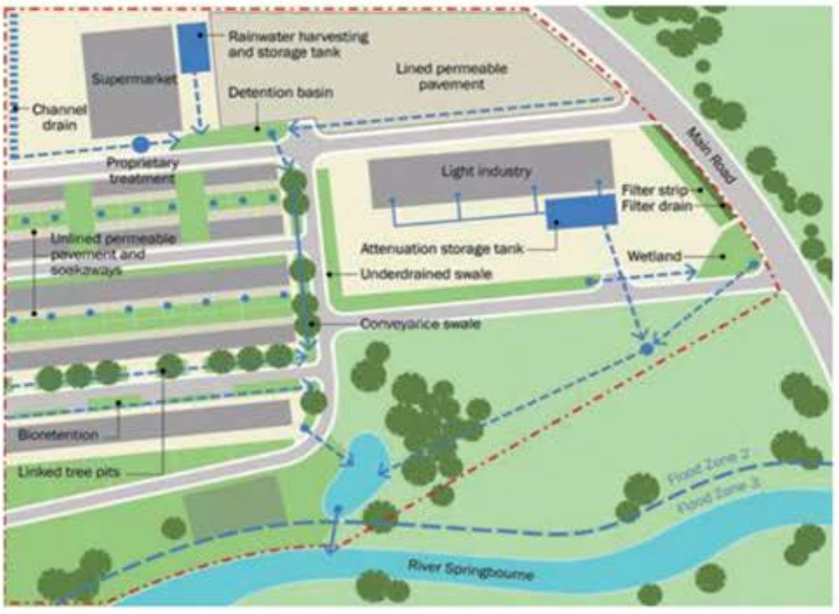

Figure 5: Overview of proposed SuDS elements and management train (Woods et al, 2015)

Figure 5 above consists of several SuDS components in combination with pipe network. Roof water from supermarket has been reused by providing rainwater harvesting system. Normally harvested rainwater is used for washing and flushing of toilets but not for the drinking purpose.

Permeable pavements have been used to provide treatment and storage of surface water from car parks. The permeable pavements provide adequate treatment to surface runoff from trafficked area, containing hydrocarbon and other metals, acceptable to the Environment Agency in the UK. The figure above shows examples of lined and unlined permeable pavements. Lined permeable pavements are used, where infiltration rates of underlying soil are very low, to provide treatment and storage of surface runoff. The unlined permeable pavement system is only appropriate where infiltration coefficient of underlying soil is 1 x 10-6m/s or greater. Filter strips, filter drains and swales used above are very effective in removal of silts, hydrocarbons and other heavy metals. In addition, treatment of surface runoff can also be incorporated within the tree roots using bio-retention.

The development in Figure 5 has used two major storage arrangements which are the underground storage tank and the attenuation pond. Generally, the underground storage tank does not provide the surface runoff treatment process except the sedimentation and maintenance of these tanks could be challenging. However, tanks are very suitable to store the surface water during the storm events where the space is limited. It can be constructed under the car parks, paved areas and green spaces. Ponds in other hands not only provide quantity and quality requirements in drainage system they also provide amenity and biodiversity benefits to the area. Therefore, ponds are always preferable than the underground tanks for the storage of surface water.

Zone 2 and Zone 3 shown in Figure above indicates the flood zones classification in the UK. There are three flood zones as defined by the Environment Agency in the UK (Environment Agency, 2018); Flood Zone 1, 2 and 3. The flood zones are based on the likelihood of an area flooding. Areas deemed to be in flood Zone 1 having less than 0.1% chance of flooding in any year, this is sometimes known as having a 1:1000year chance. Areas deemed to be in flood Zone 2 having between 0.1% – 1% chance of flooding from rivers in any year (between 1:1000 and 1:100 chance) or between 0.1% – 0.5% chance of flooding from the sea in any year (between 1:1000 and 1:200 chance). Areas within flood zone 3 to be at a 1% or greater probability of flooding from rivers or 0.5% or greater probability of flooding from the sea.

In the UK, development within Zone 3 is normally not permitted, unless these developments can demonstrate that flood risk to people and property will be managed satisfactorily, and proposal provide sustainable benefits to the community in long run. Whereas, only certain developments are permitted within the Zone 2 based on their susceptibility to the flooding.

5. Conclusions

SuDS delivers a real benefit to the society with a high amenity value to the environment by moving surface water from a problem to a valuable resource. As part of the surface water management system it also creates a high-quality refreshing public space. Studies in the UK suggest that SuDS are almost always cheaper than the conventional drainage systems and could save 10% to 50% of cost. SuDS uses the fewer natural resources and reduce the use of industrial manufacture product (concrete pipe, plastic pipes etc.) and hence helps to minimise the carbon footprint.

The use of SuDS in Nepal is very useful, especially in Kathmandu valley and the Terai areas, where groundwater is heavily abstracted for the purpose of drinking and other industrial use. If groundwater recharge is not considered on right time this could cause big impact on the groundwater hydrology in future. The local planning authority should put requirement for the use of SuDS in the drainage design for the new development in following hierarchy.

- Infiltration (swales, soakaways, filter strips)
- Attenuation and discharge to receiving water bodies;
- Surface water discharge to surface water sewers;
- Surface water discharge to combined sewer (last option).

In Nepal, soakaways are usually used to discharge the surface water without proper understanding of pollution to watercourse and groundwater. Specially, surface runoff from trafficked areas could contain high level of hydrocarbon and other pollutant including heavy metals, which could be harmful to the human health and aquatic animals. Treatment of pollutant from surface runoff is essential prior to discharge into the water body and this must be considered in design.

The soakaway should be installed at least 5m away from the any structure foundation to avoid the consequence of building foundation subsidence. Where groundwater table is high soakaway system should not be used as this will cause pollution risks. While designing the soakaways adequate thickness of soil layer to be provided between the groundwater table and base of the soakaways. In addition to the soakaways, other SuDS technologies described above should be considered in any new residential, industrial and infrastructure developments in Nepal to provide the sustainable surface water management.

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Safety improvement through the application of UK skid resistance policy in Nepalese Highways

Umesh Parajuli

Pavement Lead, Senior Engineer, A-one+, Highways England Area 4, UK

umesh_parajuli@hotmail.com

1. Introduction

Pavement safety is defined as the safety of road users to be achieved through the road pavement ideally through surface characteristics. Skid resistance (SR) is one of the important pavement surface characteristics, which is directly linked to safety of road users. Pavement safety is achieved through SR of pavement, which relates to friction between pavement surface and vehicle tyres in wet condition. SR is defined as the frictional force developed when a tyre that is prevented from rotating slides along the pavement surface in wet condition. The friction provides skid resistance of the pavement surface which in turn help avoiding vehicle from skidding. Highways (Pavement) engineer controls the level of friction or SR of pavement surface which is one of the focal points of this article. Researchers have shown that the number of wet crashes increases as pavement friction decreases (all other factors, such as speed and traffic volume, remaining the same).

The term 'road safety', although indicates the safety of the road users which can be achieved in wider ways such as through road highways design in the form of geometry; or safety element design such as vehicle restraint system (Highways Agency, 2006a); road markings, traffic signs & signals; traffic calming measures; or pavement design ideally surfacing characteristics, however this article considers the pavement safety as the road safety. This article is focused on UK practice skid resistance policy by Highways England in managing its strategic road networks and its possible application in Nepal, to improve road safety, where the country is currently facing very high rate of road casualties, a big problem, as the road network as well as vehicular traffic have been growing rapidly.

2. Statistical Background

UK roads are considered to be one of the safest road networks in the Europe ideally the safest in the world. Based on European Transport Safety council statistic (ETSC, 2017), UK had 27 road death/million inhabitants 3rd lowest in Europe after Norway and Sweden. Current measurement of road safety is based on statistical data on killed or severely injured incidents on the road networks. Most important facts on which safety of the road networks depends are safety integrated design practice, available safety regulations and its strict implementation. UK has its own fully developed design standards for roads and bridges. These standards are also complied with the safety standards such as GG 104 (Highways England, 2018) and Construction Design Management (CDM) regulation (HSE, 2015) and their implementation is very strict in practice.

Although history of SR in the UK roads begun in late 50s, many researches were carried out on level of SR and its measurements. Skid policy and standard was formally introduced in UK trunk roads first time in 1988. The policy has two objectives in which one was to improve skid resistance of the roads through use of material with appropriate properties and the next was to carry out the regular monitoring of the pavement surface through appropriate measurements. The policy and standard were reviewed and refined as appropriate from time to time. Recent statistic from Department for Transport (DFT, 2017) for the whole UK road network, 6352 fatalities recorded in 1979. Despite significant increased in vehicles, road casualties were reduced to 2946 fatalities in 2007 and 1792 fatalities in 2017. As of 2017, out of total 8343 accidents involving 203 fatal casualties recorded in the strategic road network in the UK, 833 accidents are wet skid accidents. Above statistical data shows there is a clear evidence of significant improvement (i.e. approximately 39% drop in road casualties from 2007 to 2017) in the safety of the road network in the UK with the implementation of Skid policy.

On the other hand, Nepal which is one of the developing countries but often facing political instability, which has yet to fully develop and practice safety standards and regulations of its own. Nepal is currently facing a very high rate of road casualties. There are hardly any days in which there are no news of road casualties in the media. Nepal can improve its road safety by reducing pavement related road casualties with the application of UK practice skid resistance policy in managing its strategic road network. This article is neither guidance nor an instruction, but it may serve general advice and awareness to relevant person or organisations which are working towards road safety in Nepal. This also provides some technical background, relevant statistics and focussed on the need of SR policy in managing road network based on author's experience and practice in the UK.

3. Why pavement safety is a big deal in Nepal

A study (Himalayan Times, 2017) showed that a total of 1,356 people were killed in road accidents in the fiscal 2008-09, followed by 1,734 in 2009-10, 1,689 in 2010-11, 1,837 in 2011-12, 1,816 in 2012-13, 1,786 in 2013-14 and 2,004 in 2014-15. Similarly, 12,540 were injured with 4,250 critically and 2385 persons were killed in 10,178 roads accidents in 2016-17. Although majorities of accidents are attributed to driver's negligence (due to speeding, drink driving, and recklessness of passengers, overtaking vehicles, mechanical failure, and overload), stray cattle, poor or low-standard road conditions and bad weather are other factors attributed to accidents. Another statistic about accidents in Nepal (Shrestha, 2013) shows current average annual road accidents death rate is 14 to 17 deaths per 10,000 registered vehicles. There were 1,348,995 vehicles were registered in Nepal by the end of 2012. This statistic is similar with 2013 data in Wikipedia (Wikipedia, 2018) which show 196.4 deaths per 100,000 vehicles. This also shows in Nepal 170 fatalities per 1million inhabitants as compare to 29 only in the UK and 109 in USA.

From above statistical data it is very clear that Nepal has very high, probably highest in the south Asia, rate of road casualties. Socio-economic impact of these casualties is unrecoverable. There is no doubt that some casualties are linked to road pavement characteristics such as skid resistance of the road surface which, in author's view it is either ignored in design and implementation or not known due to not having Skid resistance policy, which integrates safety standard in the design for practical implementation. Thus, safety of the road in Nepal can be improved greatly with the applications of UK practiced skid resistance policy in managing road network.

4. Science behind the skid resistance of the pavement surface

As mentioned earlier, friction between pavement surface and vehicle tyre is the important fact behind the safety of the pavement. Pavement friction is the force that resists the relative motion between a vehicle tyre and a pavement surface. This resistive force (skid resistance) is generated as the tyre rolls or slides over the pavement surface. Pavement friction plays a vital role in keeping vehicles on the road, as it gives drivers the ability to control/manoeuvre their vehicles in a safe manner, in both the longitudinal and lateral directions.

Among various pavement characteristics, texture depth (TD) and aggregate with appropriate polished stone value (PSV) have major contribution to provide skid resistance (friction) of the pavement surface. In the UK, these two parameters are the key requirements in surfacing design. In the pavement there are micro texture, macro texture and mega texture in which first two are very important properties while considering skid resistance of the pavement. Surface texture indicates macro-texture which depends on size of aggregate, micro-texture, type of surfacing, asphalt production technology and so on. Micro-texture indicates general roughness of the aggregate which provide contribute friction to be demanded for low speed driving condition. Macro-texture together with micro-texture provides overall SR of the pavement. Macro-texture has major contribution in providing friction demand during high speed driving condition. At scheme level TD is measured using volumetric patch method where as sensor measured texture depth (SMTD) method is used at network level. Figure 1 shows the difference between micro and macro texture in pavement with positive TD.

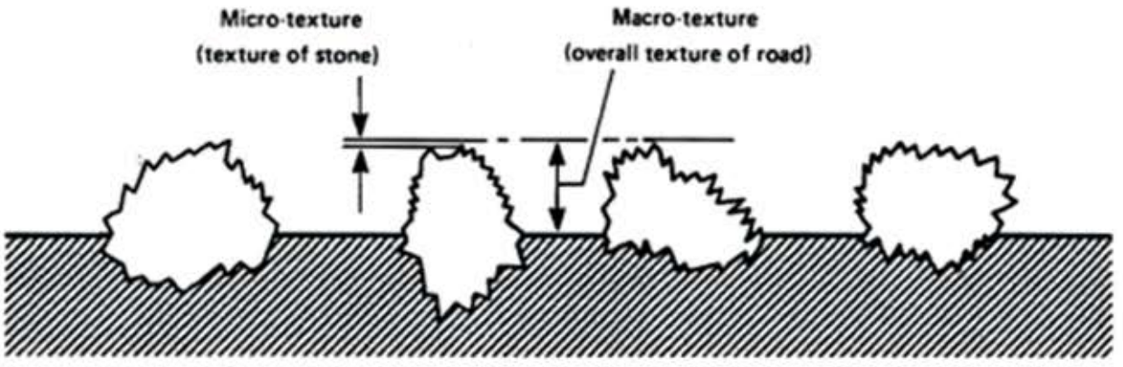

Figure 1: Difference between micro and macro texture (Highways Agency, 2006b)

Generally speaking, higher the friction available at the pavement – tyre interfaces the more control the driver can have over the vehicle. Pavement friction is the result of a complex interplay between two principal frictional force components which are called adhesion and hysteresis. Both components depend largely on pavement surface characteristics, the contact between tyre and pavement, and the properties of the tyre. Figure 2 shows adhesion and hysteresis components in the tyre-pavement interface.

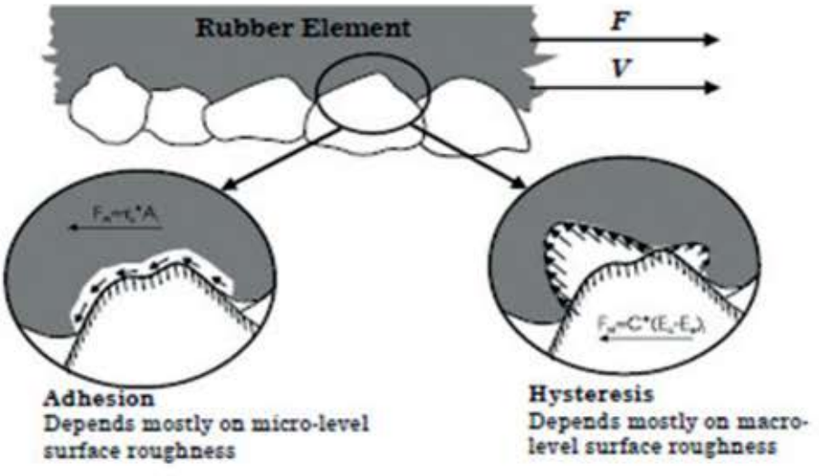

Figure 2: Adhesion and hysteresis components in the tyre-pavement interface (NCHRP, 2009)

Because adhesion force is developed at the pavement–tyre interface, it is most responsive to micro-texture of the aggregate particles contained in the pavement surface. In contrast, the hysteresis force developed within the tyre is most responsive to the macro-texture formed in the surface via mix design and/or construction techniques. As a result of this phenomenon, adhesion governs the overall friction on smooth-textured (i.e. at micro level) and dry pavements, while hysteresis is the dominant component on wet and rough-textured (i.e. at macro level) pavements.

Pavement surface requires certain level of skid resistance to avoid vehicle from skidding. While driving vehicle, breaking situation is always critical which demands higher level of skid resistance. The condition becomes even more critical when road surface is wet and vehicle requires sudden breaking.

A very small amount of water can significantly reduce pavement friction. Hydroplaning can occur when relatively thick water layers or films are present and vehicles are travelling at higher speeds. Hydroplaning occurs when a vehicle tyre is separated from the pavement surface by the water pressure that builds up at the pavement–tyre interface causing friction to drop significantly. It is a complex phenomenon affected by several parameters, including water depth, vehicle speed, pavement macro-texture, tyre tread depth, tyre inflation pressure, and tyre contact area. Relatively thick water films form on a pavement surface when drainage is inadequate during heavy rainfalls or when pavement rutting creates a shallow pool of water. Thus, drainage system to take away rain water from pavement is also one of the important factors in maintaining SR of the pavement.

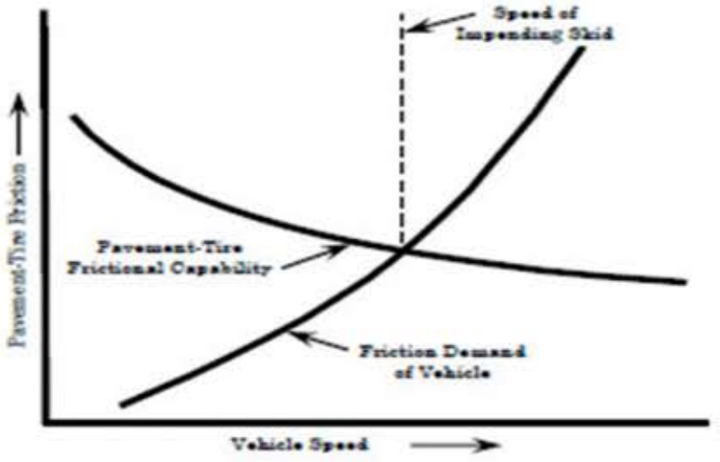

Figure 3: Relationship between friction demand, speed and friction availability (NCHRP, 2009)

Primarily, the level of friction demand (i.e. skid resistance) of the pavement surface depends on various factors such as vehicle speed, traffic volume, locations (i.e. geometrical feature such as curve, gradient, junctions and link etc) and surface condition (wet or dry). Level of SR demand also varies when the above factors are acting alone or in combinations. For instance, SR demand will be high for a junction with high gradient as compare to that with a low gradient. Figure 3 shows how the friction demand changes with speed of the vehicle.

PSV is a standard measurement of the skid resistance. It is the ability of the aggregate to resist the polishing effects of traffic which has the greatest effect on skid resistance and safety in the wet, particularly in the medium to long term life of a surfacing. PSV has been a key aspect of quarrying, specifications, aggregate selections and asphalt mix development for surfacing in the UK. PSV depends on the type of rock through which aggregates is produced. It is measured using British Pendulum tester and accelerated polishing testing machine in accordance with BS EN 1097-8:2009. In the UK, there was a relationship established to predict skidding resistance from PSV of aggregate and expected traffic level in terms of number of commercial vehicles which is the basis of current standard in the UK (Highways Agency, 2018) for PSV specification.

5. Skid resistance management in the UK road networks

In the UK, Highways England (formerly Highways Agency) [14.0] is responsible to manage (operate, maintain & improve/modernise) Strategic Road Network (SRN) (motorways & major A roads which are also called trunk roads) with primary objective to provide best service to road users and support country's economic growth maintaining environment and societal value. One of the objectives of the Highways England in managing strategic network is to keep road safe and serviceable condition for which one of its policies is to carry out skid resistance investigation annually in accordance with HD28 (Highways Agency, 2015).

As explained in earlier paragraphs, skid resistance (SR) is defined as the measure of the overall friction available between the road surface and tyre in wet conditions. In the UK, SR is one of the most important requirements of the surface course design which has direct linked to safety of road users. An appropriate level of skid resistance (i.e. pavement friction) must be maintained across all pavement sections within a given highway network. The level of skid resistance considered appropriate must be determined based on each section's or segment's SR demand in the worst driving condition. It is imperative that SR achieved from the surface at each section or segment of the road pavement always meet or exceed the SR demand.

HD28 (Highways Agency, 2015) describes how the provision of appropriate levels of skid resistance on the UK strategic road network will be managed. This Standard also describes how measurements of skid resistance are to be made, interpreted and which sets out advice on surfacing material characteristics necessary to deliver the required skid resistance properties.

The objective of the skid resistance investigation is to identify skid resistance deficient areas for the potential risk of wet and skidding accidents and also to identify whether any form of treatment would be justifiable. SR investigation is one of scheme identification criteria in Pavement asset management system.

Although demand of SR varies with different situation (geometry, weather, speed limit, traffic and so on), geometrical implications are very important in deciding level of SR demand. Thus, each road is categorised into various 'Site Category' based on risk of skidding for the same level of road speed limit. Each road category requires specific level of breaking in the form of SR. Site categories allow the required level of skid resistance to be varied based on the geometric constraints of the road. The minimum level of SR demand is expressed in terms of investigatory levels (IL). IL can also be considered as minimum design requirement of SR in pavement surfacing design. Table 1 (Highways Agency, 2015) shows various Site Categories and appropriate Investigatory Level (IL) which are currently adopted in the UK SRN.

Table 1: Site Category and Investigatory Level (IL) (Highways Agency, 2015)

Site Category and definition		IL for CSC data (Skid data speed corrected to 50km/h and seasonally corrected)							
		0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65
A	Motorway								
B	Non-event carriageway with one-way traffic								
C	Non-event carriageway with two-way traffic								
Q	Approaches to and across minor and major junctions, approaches to roundabouts and traffic signals (see note 5)								
K	Approaches to pedestrian crossings and other high risk situations (see note 5)								
R	Roundabout								
G1	Gradient 5-10% longer than 50m (see note 6)								
G2	Gradient >10% longer than 50m (see note 6)								
S1	Bend radius <500m – carriageway with one-way traffic (see note 7)								
S2	Bend radius <500m – carriageway with two-way traffic (see note 7)								

At network level, Sideways Force Coefficient Routine Investigation Machine (SCRIM) measures skid resistance of the pavement as the Sideway Force Coefficient (SFC) at 50MPH speed, which later converted to standard Characteristic SCRIM Coefficient (CSC) after seasonal correction is made. Highways England carry out annual SCRIM survey on its road network and survey data are stored in Highways Agency Pavement Management System (HAPMS) in the form of CSC averaging for each 10m or 100m sections of similar site category and IL. This data is later analysed for further investigation in line with standard HD28. Figure 4 shows the machine used for SCRIM annual survey at network level.

Figure 4: Sideways Force Coefficient Routine Investigation Machine used for S CRIM survey at network level in the UK (Source: WDM, UK)

The investigation process begins with the analysis of CSC data to identify sites for which CSC are at or below the investigatory levels (IL), which, together with crash history, is prioritised for the detailed investigation which then finally identify sites (section/segment) that need some form of treatment to improve SR to the level which meets the SR demand in the worst case (i.e. in the wet weather condition) driving condition. Measured CSC below the IL indicates the site may be defective that the existing SR may not be enough to provide safe driving condition. In other words, the section or segment may be unsafe for driving for which attention may be required.

Information obtained from the detailed site investigation, along with associated accidents and pavement condition data, are used to determine whether the site needs treatment (i.e. known as 'Treat sites') to improve skid resistance or does not need treatment, which will be monitored (i.e. known as 'Monitor site'). Due to safety reasons, all 'Treat sites' (that includes SR deficient areas) are considered as high priority defects for scheme development and funding for construction by the road authority (i.e. Highways England) in its forward asset management plan which are then, developed as pavement maintenance schemes through value management (VM) process.

In maintenance design, Pavement Engineer then recommends appropriate treatment method which will improve TD and PSV such that SR will be improved. As a proactive measure, each 'Treat' site are undertaken by installation of slippery road warning signs (SRS) for the period until the appropriate treatment is carried out permanently or decides monitor in the next investigation.

6. Application and benefits in Nepal

Nothing can be important than road user's safety. UK practiced skid resistance policy in managing the road network can easily be adopted in Nepal. Government should provide vision and policy in wider level towards safety of the road users which the Department of Roads (DoR) as the road authority to implement in two stages. Firstly development of standards and specification is required which shall integrate safety requirements. Secondly, above developed standards and specifications to be implemented through routine maintenance or renewal programme.

The application of the skid policy, which is UK technology transfer, can be planned through short term to long term application. Development of design standard (should include site category, Investigatory level, investigation process and procedure) and specification (should include TD and PSV for particular situation) to be planned as a short term application. Government Skid policy should include strong commitment of safety improvement by reducing road casualties. DoR can initially use UK standard (i.e. HD28) with some relaxation until few experiences are gained. Few researches will required to understand performance of the materials including local aggregates to develop required level of specification. Few pilot projects/trials with considerable lengths of roads can be started in short term plans.

Long term plans should include application of standard and specification developed to all major strategic highways for maintenance and new construction or rehabilitation. The least recommended application is to be annual network level SCRIM survey of strategic highways to identify the skid resistance conditions of particular road segments/sections. Mandatory application of TD and PSV requirements to surface course design is another recommendation.

Implementations of above recommendations are neither very difficult nor expensive to implement if the government and relevant authorities in Nepal are serious with the current state of road casualties and its socio-economic impact. The main benefit from the application of UK skid policy will be the improvement of the road user's safety. In other term there will be significant reduction of the road casualties that are linked to pavement surface condition.

7. Conclusions

Skid resistance (SR) is defined as the measure of the overall friction available between the road surface and tyre in wet conditions. In the UK, appropriate level of SR requirement is one of the most important requirements of the surface course design which has direct linked to safety of road users in wet condition.

Texture depth (TD) of the pavement and aggregate with appropriate polish stone value (PSV) that is used in the surface course mainly provide skid resistance (friction) of the pavement surface. These two parameters (i.e. TD & PSV) are the key requirements for pavement surfacing design in the UK.

Road user's safety is one of the major objectives of the Highways England in which Highways England carry-out SCRIM survey annually as part of network maintenance and monitoring, to identify SR deficient areas which then receive main priority in annual maintenance programme for delivery. HD28 and CD236 (i.e. former HD36/06) provide standard guidance for measuring and managing skid resistance policy in the UK.

Nepal is currently facing a very high rate of road casualties as one of safety problems can have significant benefits towards its road safety improvement with the application of UK practiced skid resistance policy in managing its highway network. Government's strong and committed safety improvement policy and road authority's (i.e. DoR) short term to long term plan are required. Short term plan should include standard and specification development to be followed by long term plans, which should include regular monitoring of the road network through annual SCRIM survey. Author of the article believes that UK skid policy if applied correctly can significantly improve the safety of road user's in Nepalese Highways.

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Electricity Reliability: National Grid UK- an example to follow

Subhash Shrestha

Freelance Consultant -Power System Protection & Control Specialist

subhash.roshi@gmail.com

1. Introduction

The reliability of an electricity supply system reflects its ability to maintain service continuity. In this context, the service is to make electricity available for use to the end-user customers of the electricity supply system. When an electricity supply system fails to perform this task, there are customers that experience service interruptions. Reliability of electricity supply is primarily concerned with duration and frequency of such service interruptions (Roos, 2005). Thus, reliability of supply is a customer-oriented quantity that does not consider the origin of the causes of interruptions. The reliability of supply thus depends on the performance of generation, transmission and distribution, Figure 1 shows a typical electricity network. Availability is often used as one measure of reliability. Availability is defined as the percentage of time a customer is uninterrupted. Availability is considered as a subset of reliability as it only provides information about annual interruption duration, and not about interruption frequency

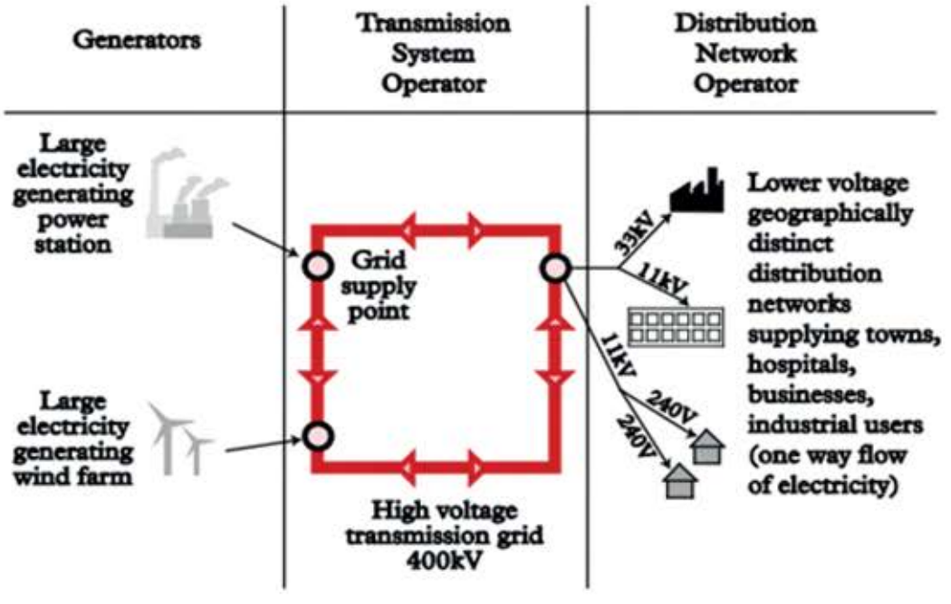

Figure 1: A typical electricity network

1.1 Interruption Costs to Customers

Access to electricity supplies at reasonable cost and quality levels has become a basic condition for development, economic growth and welfare. The more developed societies are, the more vulnerable they are to electricity supply interruptions. This dependence on reliable electricity supplies implies that costs are associated with electricity supply interruptions. For companies, electricity supply interruption costs are strongly related to production losses and to costs involved in restoring production. In addition, interruptions may also cause property damages, both for companies and for private individuals. Wide-spread long-lasting blackouts put the vulnerable society to the test and involve extra expenses required to maintain tolerable living conditions. Then there is the aspect of inconvenience and suffering of which it is difficult to estimate the value. The size of these economical losses depends largely on the composition of the customers that experience interruptions. In interruption cost surveys, customers are roughly divided into five categories: residential, agricultural, commercial, public sector and industrial customers. This customer categorization can of course be refined. The cost that each customer category relates to interruptions varies and consequently the willingness to pay for reliability improvements varies among the customer categories.

Another factor that influences the costs incurred by the customers due to interruption of electricity supplies is whether the interruption has been notified or not. The network company can schedule the notified interruptions to occasions less inconvenient to the customers and the notification allows the customers to get prepared for the interruption. It is a fact that our society is becoming increasingly dependent on electricity supplies as time elapses and therefore, the cost of supply interruptions also increases.

1.2 Interruption Costs to Utilities

Interruptions, of course, cost utilities money. These costs are related to

- service restoration (damaged equipment, labour)
- lost revenue
- legal liabilities such as damage claims from customers.

1.3 Planning and Operational Criteria

Today, the fundamental principle behind the planning for reliability in distribution systems resembles the (n-1)-criterion for transmission system operation: a distribution system should always be designed and operated in a way that allows for quick restoration of supply in the event of any single failure of equipment.

1.4 Regulations

Owning and operating electricity transmission and distribution systems are natural monopoly businesses. To prevent these businesses from taking advantage of their dominant market position, they are subject to regulation. Regulatory authorities are mandated to protect the interests of the society by setting rules for the electricity network companies. The electricity network regulatory methods applied differ between countries, however the main goal of the regulation is the same, i.e., to secure electricity supplies at acceptable levels of quality and at reasonable tariffs. The electricity network companies are obliged by their shareholders to maximize their profit by being cost-efficient. Cost-efficiency for electricity network companies usually means keeping costs as low as possible, while still meeting the requirements of the regulatory authorities. Thus, regulations should provide electric network companies with incentives to be cost-efficient in a way that benefits the society.

2. Electricity supply in Nepal

Nepal, for many years, experienced load shedding of 10-16 hours per day and has just managed to come out of it with appropriate management of load and priority setting. Until the end of Maoist insurgency, only 25% of population had access to electricity. Now the data show that the figure is now 87%. The country requires significant investment in the electricity generation using hydropower and other renewable energy sources to avoid dependency on imported power supply. Table 1 shows the plan for electricity generation in near future, which will be sufficient to avoid load shedding for at least domestic consumers. The other consideration required is to minimise the loss of electricity in the transmission network. Now the real focus has to be on delivering reliable electricity supply. There are a lot of things that should be learned from developed countries such as the practices in the UK. The focus should be in developing a system which can drastically improve reliability of electricity supply.

Table 1: Electricity generation power plants and projects (NEA, 2018)

S.No	Thermal Power Plants	Capacity(KW)
1	Duhabi Multifuel	39,000
2	Hetauda Diesel	14,410
	Total	**53,410**
	Solar Power Plants	
1	Simikot	50
2	Gamgadhi	50
	Total	**100**
Total Major Hydro(NEA)-Grid Connected		503,394
	Total Small Hydro(NEA)-Isolated	4,536
	Total Hydro(NEA)	507,930
	Total Hydro(IPP)	512695.4
	Total Hydro(Nepal)	1,020,625
	Total Thermal(NEA)	53,410
	Total Sola(NEA)	100
Total Installed Capacity		**1,074,135**
Total installed Capacity(NEA & IPP)-Grid		**1,069,499**

Under Construction		Capacity(kW)
1	Upper Tamakoshi Hydropower Project	456,000
2	Tanahu Hydropower Project	140,000
3	Kulekhani III HEP	14,000
4	Upper Trishuli 3A HEP	60,000
5	Rahuganga HEP	40,000
6	Upper Sanjen	14,600
7	Sanjen	42,500
8	Rasuwagadi	111,000
9	Madhya Bhotekoshi	102,000
1	Upper Trishuli 3B	37,000
	Total	**1,017,100**

Going forward, the real challenge for Electricity Market in Nepal and it stakeholders now is reliability and security of supply. If this can be achieved, many positive changes can be brought into cities, rural communities, industries and overall standard of life in Nepal.

3. Electricity in Great Britain

UK has one of the most resilient electricity networks in the world with impressive reliability figure of 99.999962% (see Figure 2). It is not practical or even possible to copy everything from UK to Nepal. However experiences, technologies and models can be shared and adapted to Nepal's market environment.

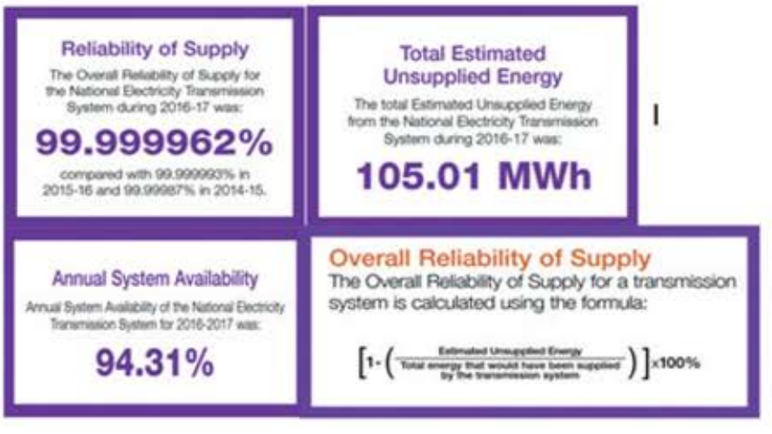

Fig. 2: UK electricity supply reliability data (National Grid, 2018)

System performance is monitored by the estimated unsupplied energy from the National Electricity Transmission System for each incident. During 2016 -17 there were 596 NETS events where transmission circuits were disconnected either automatically or by urgent manual switching (National Grid, 2018). The vast majority of these events had no impact on electricity users with only 29 resulting in loss of supplies to customers. Figure 3 shows the institutional framework for regulation of the electricity industry in Great Britain.

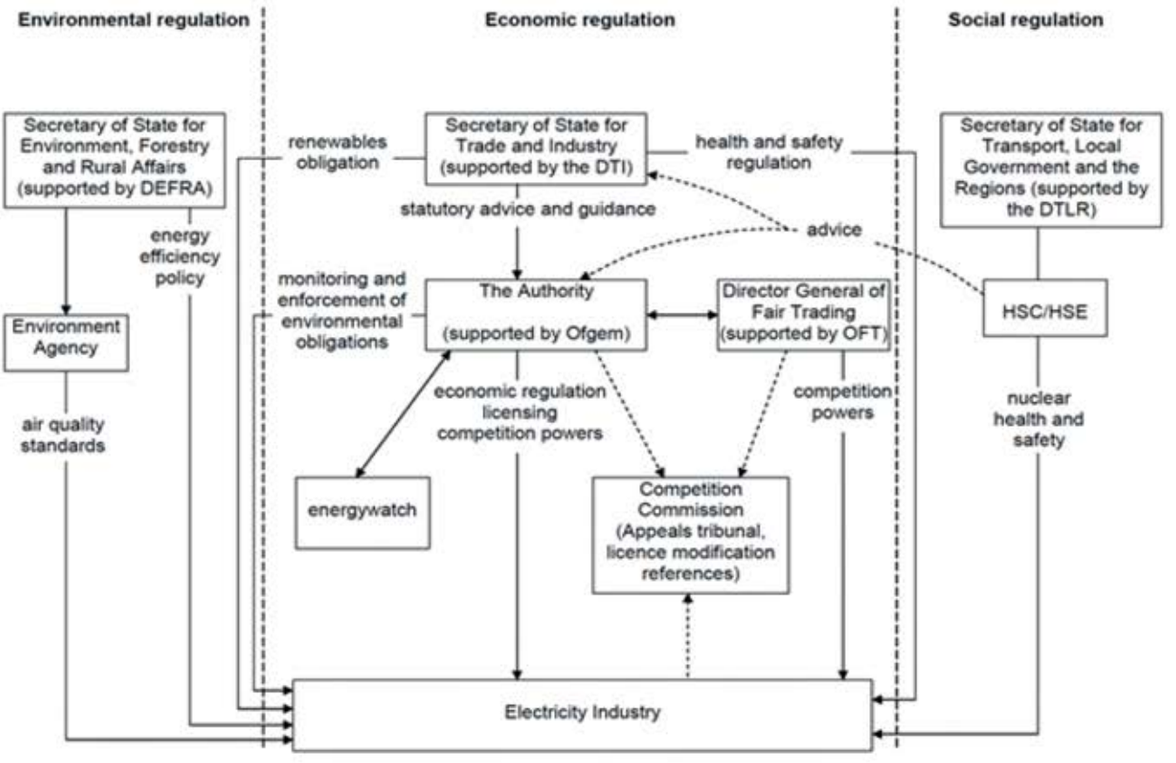

Fig. 3 Institutional framework for regulation of the electricity industry in Great Britain (Simmonds, 2002)

There are three main players responsible for secure and reliable electricity in the UK: Ofgem, National Grid and the Government.

3.1 Ofgem (Office of Gas and Electricity Markets)

Ofgem as a regulator ensures that market arrangements are sufficiently designed to encourage security of supply. It also approves the introduction of balancing services and regulate these indirectly through the cost recovery mechanisms to ensure that any service procured is in the interest of consumers.

3.2 National Grid

As the electricity system operator (SO) for Great Britain, National Grid is responsible for balancing the electricity system by ensuring that generation on the national electricity grid matches demand on a second-by-second basis. To do this, the SO buys and sells energy and procures associated balancing services. It also provides valuable information to market participants and can propose changes to market arrangements through industry codes.

3.3 Government

The government sets overall policy objectives, including on security of supply, for example through primary legislation. The government can also act reactively using emergency powers in certain circumstances. It has also set the target level of generation adequacy for GB's electricity supplies in the context of the CM (Capacity Market), the reliability standard.

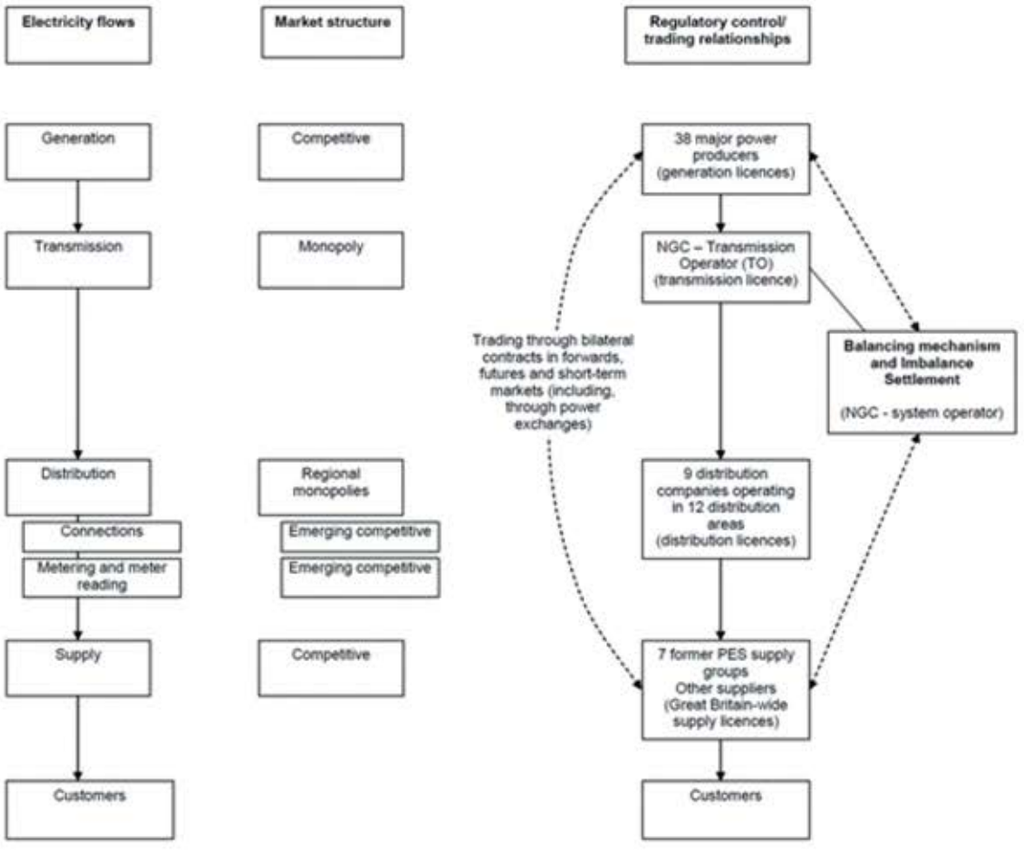

Figure 4: Structure of electricity industry in England and Wales (Simmonds, 2002)

Figure 4 shows the structure of electricity industry in England and Wales. Similar or slightly different models are there in Scotland and Northern Ireland. These block diagrams just give us snapshot view of the system working for a secure and reliable electricity ("keeping the lights on") in the UK.

For National Grid, it is mandatory for them to publish the reliability score every year for each section of the networks. Reliability score acts like a driving force for all management to entry level employees to do better to keep the score at the highest. Any effort towards higher reliability are either incentivised or provided some form of recognition. These may encourage to work towards it. But main target is to make all the stakeholders aware about the importance of the reliability of supply.

4. Conclusions

This paper discussed the importance of electricity reliability and how it is maintained at high level in the UK. However, this very important reliability score is missing from NEA (Nepal Electricity Authority) annual report. Inclusion of such data would provide a base line and the idea of challenges that needs to be addressed to achieve the goal.

Technically engineers and managers in Nepal are very capable in their fields of expertise. With the limited resources, training and exposure, they have to deal with a lot of challenging problems in wide range of fields. The engineers working in the UK, who have experience and exposure to collaborative working system, best practices, data and knowledgebase can support in the initiatives to improve the reliability of the electricity supply in Nepal.

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Necessity of Quality Management System in Nepal's Construction Works

Sudib KC

Quality Manager, Alstom, 175 High Holborn, London, UK

sudib50@hotmail.com

1. Introduction

Quality Management System is an organisation's planned approach to ensuring that the organisation achieves its objectives. This is applicable for manufacture of products, construction of infrastructure, providing services, and implementing processes. Without an effective quality management system, it cannot be guaranteed to customer or end users that they are using the proper quality things. To maintain quality, the quality management system and the quality control of the product to be focused.

Quality starts from the design stage. Quality is the most important factor during the selection of the contractors, procurement of the materials and implementing the construction works. Proper supply chain management should be implemented to enhance the quality in the construction works. It is very difficult to maintain quality of construction works in developing countries because of inadequate quality management plans, procedures, poor use of correct quality management concept and inadequate quality control processes.

This paper presents an outline of a quality management system, which can be helpful to enhance the systematic delivery of quality outcomes and to improve the control of quality during construction works in Nepal. This paper has been developed using the DRONE concept to simplify the quality management system. DRONE meaning is - "BUZZ" OR "THRILL".

Figure 6: DRONE Concept

2. Implementation of DRONE Concept

The DRONE (Design Resources Operation Nonconformity and Enrichment) concept should have measurable criteria to enable tracking of the DRONE processes. Gate reviews should be performed to control progression (go/no-go) from one activity to the next. To manage the DRONE concept, various procedures and plans are to be agreed. Procedures and plans help to drive the process and it provides efficient and effective control during the construction works. Table 1 has been illustrated the DRONE concept.

Table 1: Process of DRONE Concept

DRONE Concept	Activities	Gate reviews	Management Procedures	Management Plans
Design	Correct design drawings Correct use of specification, norms and Standards	Gate 1 design review	Management of Drawings	Contract Quality Plan
Resources	Contractor selection Involvement of Competent Personnel	Gate 2 Selection of contractors and suppliers review	Quality Audit Procedure Procurement procedure Competence Management Procedure	Contract Quality Plan
	Correct use of material & plant	Gate 3 Material and plant procurement review	Material approval procedure	
Operation	Implementation of works Briefing of work activities Tool box talk for critical activities Quality control process during the works undertaken (Table 3)	Gate 4 start of the work review	Calibration of test equipment Procedure Method Statements Procedure Inspection and Test Plans procedure Snagging Procedure	Contract Quality Plan
Non-conformity	Follow standards according to design and specification Performance evaluation of the works undertaken	None	Quality Surveillance Procedure Management of Non-Conformities	Contract Quality Plan
Enrichment	Improvement of defects Problem solving root cause analysis Lesson learnt to prevent reoccurrence of failure	None	Defect improvement procedure	Contract Quality Plan

3. Overview of management plan and procedure

3.1 Contract Quality Plan

The Quality Management System shall be in accordance with ISO 9001:2015. The Quality Plan drives the procedures to implement the works correctly according to the client/customer work information and the Quality Management System. The Quality Plan applies to all stages of the project and is to be reviewed and revised as necessary according to the project requirements. Associated documents such as procedures, work instructions and many supporting documents are to be developed separately and those documents need to be updated regularly.

3.2 Management of drawing procedure

The purpose of this procedure is to ensure the correct way of producing the construction drawings and the responsibilities of the personnel involved to issue the right drawings to the construction team.

3.3 Quality Audit Procedure

The purpose of this procedure is to ensure the audits are done consistently and in line with ISO 19011 (guidelines for auditing management systems). Quality audits should be scheduled out using a risk-based approach to provide assurance that the organisation's quality management system is being implemented effectively and to identify areas for improvement. The audit schedule should be prepared according to an analysis of appropriate risk factors (Table 2). These factors allow the organisation to evaluate the quality risk associated with each aspect of the organisation's management system or their activities and so to focus the audit schedule where it will provide most valuable insight.

Table 2: Risk factor analysis

Risk Factor	Range of values	Definition
Effectiveness of contractors and supplier's internal quality audit process	1 to 5	Effective to Ineffective
Project criticality	1 to 5	Minimal to Supercritical
Quality reputation of previous projects	1 to 5	Excellent to Poor
Quality document assessment	1 to 5	Excellent to Poor
Understanding of works	1 to 5	Undeveloped to Innovative
Risk of non-conformance	1 to 5	No concerns to serious concerns
Contractor's opportunity to realise the defects	1 to 5	Effective to Ineffective

3.4 Procurement procedure

The purpose of this procedure is to ensure to select suitably competent, qualified and capable contractors to undertake the work correctly, and to ensure that all requirements necessary for proper execution of the work are included in the supply contract. During the selection of contractors, their quality competence, qualifications and capability are to be thoroughly scrutinised to ensure they meet contract and organisation requirements.

3.5 Competence Management Procedure

Competent means suitably qualified and experienced person (SQEP). Competent people are required to carry out the works that they have been given. The organisation must ensure that personnel who carry out design, installation and inspection activities have been assessed as competent. Those personnel assessments are to be done by a suitable senior competent person completing the appropriate competency assessment form. The competency assessment form to be reviewed and agreed by the competent personnel as well. Objectives, roles and responsibilities of the personnel required for the project should be carefully described in a Role Specification. This will ensure that everyone in the project team understands clearly what their role is and the role of others in their team.

3.6 Material approval procedure

The purpose of this procedure is to ensure that all materials, products and plant procured for the works are in compliance with the requirements of the project contract, including all applicable standards and legislation and that acceptable evidence of compliance is provided for every item before it is procured.

3.7 Calibration of test equipment procedure

The purpose of this procedure is to manage the calibration of the test equipment. All test equipment that are used for installation, inspection, measuring and test activities should be functioning reliably, within acceptable limits of deviation and that records must be kept correctly on the appropriate log.

3.8 Method Statement procedure

The purpose of this procedure is to ensure that the methodology and the task briefings produced for the works to minimise risks of error and so describe how the work is to be carried out and completed without error, right first time.

3.9 Inspection and test plan procedure

Inspection and test plan (ITP) is the most important part of the operation to ensure all works are carried out in accordance with specification and standards. ITP must contain the works description, control documents, responsible competent personnel to inspect and the inspection intervention for hold point. It means, without successfully completion of one item, next item cannot be proceed. Appropriate inspection and test plan template and quality control check sheet must be used to control the operation. The records produced will demonstrate that the work meets the design requirements and so is suitable for functional testing.

3.10 Quality Surveillance procedure

This procedure will help to ensure the works are carried out in accordance with specification and standards, including codes of practice and manufacturer's instructions. Surveillance provides an opportunity to examine conformity of the works, including materials, products and plant against the specified parameters.

3.11 Management of Non-Conformities procedure

When any aspect of the work is found not to conform to the design requirements the organisation must correct the work or get agreement from the designer and customer on what to do about the non-conforming work. The organisation must also understand how the non-conformity happened and make suitable changes to ensure the same mistake cannot happen again. This procedure explains the process for managing non-conformities effectively and for ensuring that appropriate action is taken to prevent reoccurrence of the non-conformity. Root cause of the non-conformity must be identified. Corrective action to be implemented for short term rectification and proper preventive action to be identified to prevent a similar problem arising. The root cause and preventive action should be escalated to all responsible personnel by using various methods, such as Lessons learned, briefing, tool box talk etc.

3.12 Quality improvement procedure

This procedure explains how the organisation will enhance the control and prevention of defects. Lessons learned, tool box talk and briefing can be used as tools to communicate good quality practice and learning from management of previous defects.

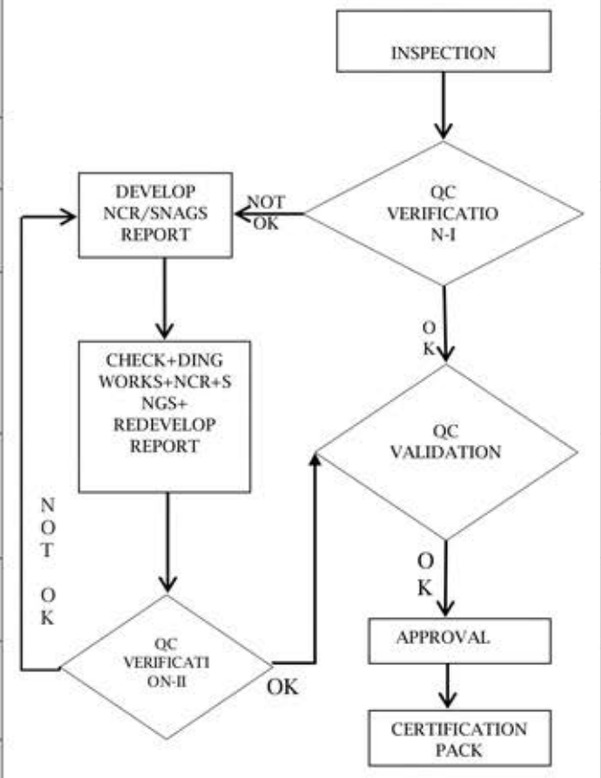
3.13 Management of snagging procedure

This procedure explains the process and controls to be applied to the management of minor quality issues encountered during final inspections. The process allows for a strict control over the management of defects, snags and any outstanding work to complete the project. An appropriate template is to be used to log the snags and the snag closure evidences must be recorded.

4. Quality Control Process

Quality control process is used to control operation stage of the DRONE concept. Table 3 has been illustrated the quality control process.

Table 3: Quality control process

Activity	Flow Chart	Person In charge	Documents Required
Develop Inspection and test plan +quality control check sheet		Site Engineer/Site supervisor	Signed and dated quality control check sheets
QC Verification-I		Quality inspectors	Signed Quality verification sheets
Develop Reports		Quality control Engineer	Verification report
Check + Close outstanding works+ Redevelop quality inspection sheet		Site Engineer/Site Supervisor	Signed and dated quality sheets. SNAG closure photos, NCR corrective and preventive action
QC Verification-II		Quality inspectors	Signed Quality verification sheets
QC Validation		Quality Engineer	Name, date and signature on Quality sheets
QC Approval		Quality Manager	Name, date and signature on Quality sheets
Quality Certification		Quality Assurance	Quality Certification Pack

5. Conclusions

There are many concepts to elaborate the quality management system. However, DRONE concept is a simple and an informative quality management system that can be implemented in Nepal's construction industries. To have a better quality management system, including the author's write up, below information are also very important to support the DRONE concept.

- All construction companies shall be accredited with ISO9001:2015 quality management system
- All construction companies shall prepare their own Quality Plan
- Importance of quality management plans and procedures shall be properly addressed in the quality plan
- Quality plan and procedure shall be revised regularly as required

The scope and benefits of computer games in the context of Nepal

Sanyukta Shrestha

yantrakala ltd, UK

sanyukta@yantrakala.com

1. A brief history of the global gaming market

While the first television games were limited to laboratories in the 1950s, they found actual consumer market in the 1970s. By 1980s, their popularity multiplied manifold and the console moved from television screen to computer monitors. Gaming gradually made its way to handheld devices and the first mobile games emerged by mid 1990s. While Nintendo and Playstations maintain a stronghold in PC gaming industry the mobile gaming experience demonstrated a radical increase following the potential of creating new consumer base who were formerly uninterested in gaming. The major event that contributed to this scenario being the release of Apple AppStore in 2008 (Noyons, 2012).

2. Global mobile gaming market and Nepal

According to AppStore, the top app download for Nepal is Facebook and Messenger, whilst the most popular among those released by Nepal is HamroPatro at top 14th as of December 2018. While HamroPatro in itself is not a gaming app, there are two other interesting facts to note. The top gaming app on mobile devices for Nepal is none other than Ludo Neo-classic which proves that popularity of Nepali gaming industry is based on traditional knowledge and not sophisticated ideas. It is worth noting that the urban user-base is much limited as compared to overall population well below the required literacy rate. Although less popular as compared to emails and social media apps, but still at the top 20th position, the fact that Ludo Neo-classic is developed by an individual as compared to bigger software establishments, means the industry is not necessarily reliant on bigger investments.

In the UK, gaming continues to be one of the top activity for smartphone users (47%) which is slightly below the top activity of checking weather (56%) and emails (52%) according to a 2017 survey (UKIE, 2018). Meanwhile in Asia, China's wait to become the world's largest market in iOS AppStore ended in 2016 with a figure of $1.6 billion, mainly with introduction to augmented reality with hugely successful Pokemon Go (Sydow, 2016). While the world gaming market was valued at $100 billion in 2017 and forecasted to reach more than $128 billion by 2020 (newzoo, 2017), Nepal's other nearest neighbour, India, was not expected to contribute more than 1% of global consumer spend despite its 111% growth forecast for 2017 (App annie, 2017). Given Nepal's socio-cultural similarities with India, these figures show a challenge that Nepal faces in this area.

With no specific survey carried out in national or international level regarding the gaming industry of Nepal, much of our inferences can only be based on Asia-wide figures correlated to Nepal's national share in mobile consumer base. However, the global and regional growth rates in both hardware and software penetration aided by Nepal's national policies for tariff economy and introduction to newer technologies can be the major players in defining the future of mobile gaming market in Nepal.

3. Nepal's foray into mobile gaming

The fact that mobile devices have a greater potential to offer gaming consumer base as compared to desktop is clear from global statistics and was already a matter of research priority by 2010 (Maurer, 2010). In the last decade, many surveys cited soaring figures for mobile usage over desktop e.g., mobile usage as 77.7% as opposed to 22.3% for desktop (Fluent, 2016), and the equation seems more inclining towards mobiles by every passing year. Given the scenario, Nepal's foray into mobile apps started with a number of start-ups led by smaller teams of youth engineers and entrepreneurs. Whilst the massive 2015 earthquake inspired such teams to innovate more towards solving problems created by the natural calamity, e.g., resource mapping, and facing the subsequent economic blockage by India, e.g., carpooling, very less ground was possibly left for entertainment.

It was not until 5th January 2017 that one of the most popular mobile games Haku Run, and the first to be based on a Nepali movie, was released by a new start-up (Nagariknetworkcom, 2019). Not the best in terms of visual presentation and graphical optimisation, the game managed to hit a record download figure of 10,000 in less than 3 days of its launch. Whilst piggybacking on newly gained popularity of Nepali movies sounded just right, the idea continued for a few more movies in turn and fizzled soon after. Beyond aiming for entertainment and more than being a vehicle for publicity of some other major product, gaming is yet to find a more meaningful purpose to help address serious issues of the country. The scope for exploring such avenues will be covered in rest of the paper.

4. Scope of gaming in Nepal

With Nepal Telecommunication Authority citing only 2% phone users with landline and the rest 98% with mobile phones in 2018 (NTA, 2018), there cannot be a better time to explore mobile gaming as a means to improve grave situations of community health and literacy in Nepal. The same report also confirms that 78% of the subscribers use mobile internet in Nepal, which further opens up possibilities for online and multi-player interactions to enhance their gaming experience.

4.1 Healthcare

According to the 2015 data from World Health Organisation, the life expectancy of an average Nepali is 68 years (WHO, 2015), which, though not alarming for Central and South Asia, is reasonably lower than figures above 80% in United Kingdom, Canada, Australia and Japan. Although maternal mortality has been reduced from 850 in 1990 to 258 in 2015 according to UNFPA report (UNFPA, 2015), only 36% of child birth is assisted by a skilled provider (doctor, nurse or midwife) and 60% of women receive some antenatal care from skilled provider (MOHP, 2011) which leaves enough ground for improvement.

Communicable diseases

While Malaria, Tuberculosis and HIV/AIDS top the major infectious and communicable diseases in Nepal (Thapa, 2013), the reasons are generally one or more from safe water, sanitation, hygiene and healthcare waste management that need to be controlled in community level. Accurate identification, diagnosis and report of above diseases is a challenge due to remoteness, urban-centred healthcare infrastructure and lack of professionals and laboratories.

While developing countries like Nepal have a long way to go for a satisfactory infrastructure and healthcare facilities to prevail throughout, other effective solutions towards controlling of communicable diseases can be community awareness and inclusion in primary level education. Gaming platforms have huge potential in facilitating awareness in adult population and education at primary level, thereby influencing the scenario of community healthcare.

Non-communicable diseases

On the other hand, non-communicable diseases which constitute of 60% of all deaths in the world, appear as an extra burden to Nepal's healthcare scenario which is already struggling with the control of communicable diseases (4.a.i). A simple hospital based study in Nepal has revealed hypertension, lung conditions and diabetes as major non-communicable diseases (Neupane and Kallestrup, 2013) accounting for 44% of deaths and 80% outpatient contacts.

As the risk of these diseases is raised by tobacco use, physical inactivity, unhealthy diet and harmful use of alcohol, such risk factors can be disseminated to wider community through multimedia messages and gaming platforms more effectively. Owing to the fact that non-communicable diseases have a wider presence in urban areas, the importance of gamifying healthcare education cannot be undermined.

4.2 Case Studies

This section discusses the experiences of developing gaming apps whilst working for Prabidhi Nepal in 2004, which will be illustrated here as case studies. They were online and offline multimedia projects with substantial gaming elements incorporated in their human-computer interface (HCI). Their target users included communities with lower literacy rate and lesser healthcare facilities in immediate reach.

Figure 1: Primary health information system

A primary health information system (Figure 1) which was built as an offline tool for use in those regions where skilled healthcare providers were scarce or unavailable. Conceived as an action against digital divide, this software system helped to identify several diseases including Chest infection and Diarrhoea in child patients. With an ability to easily extend the list of identifiable diseases as external plugins, the system asked several questions before coming to a final conclusion. As a decision-making tool, it eventually suggested household cures for the identified diseases. The element of game play was in avoiding text references but play animated visuals and audio recordings in local language, hence making it usable for communities with lowest literacy rate.

Healthcare locator

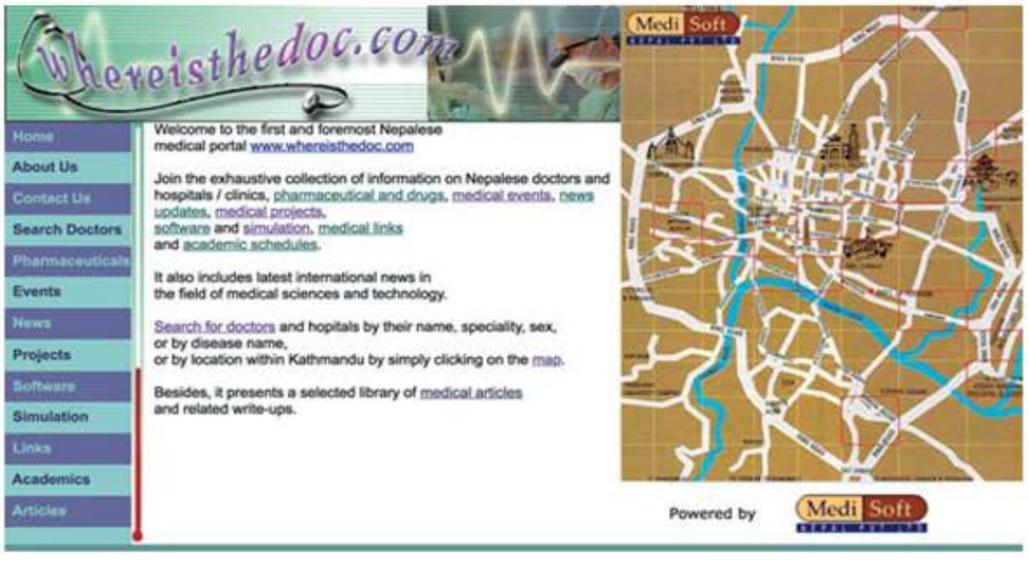


Figure 2: Healthcare locator

Developed as an online portal and accessible through Internet over all browsers, a healthcare locator (Figure 2) was developed with exhaustive collection of information on hospitals, medicines and medical projects. Using mapping technology, a town area within the country was divided into a grid structure where each cell was clickable to produce up-to-date medical information available in the system e.g., details of a doctor or a specialist of a certain disease. Users of the system could also search for doctors and hospitals by their name, speciality, and sex. The element of gameplay incorporated in this system was much subtle as the questions leading to a point of decision making was not direct. Rather than pure gaming, the interactions involved could be terms as multimedia interfaces. As of 2004, touchscreens had not yet hit the consumer market so the interface was limited to mouse clicks only.

4.3 Education

In Britain, for instance, primary level education has already accepted the importance of gamifying the process of teaching and learning various subjects as basic as mathematics, English and history, to as specific as fundamentals of computer programming or coding. Even third-party products have been introduced in school-level curricula including freely available and child-safe technologies. The same is not yet true for Nepal. Introduction of gaming technologies in education sector can facilitate the process of learning, making it more fun and receptive for the younger generation.

Beyond the textbooks, more of relevant social and practical knowledge can also be imparted through gaming technologies e.g., earthquake preparedness, heritage awareness, ethical issues and even sports sciences. Although it may not be the case with remote villages, for those regions with easy access to technology, augmented and virtual reality systems are also in place to help their users go through near to real life experiences that help better understanding.

5. Conclusions

This paper attempted gaze into Nepal's mobile Internet and gaming market as compared to national, regional and global statistics, which could facilitate initial stage of project plans that require market research, feasibility analysis and estimation of funding. Several areas are identified where gaming can bring fruitful results for developing countries like Nepal in line with their priority sectors. Few relevant projects have also been illustrated to show simple examples of gaming in those priority sectors.

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Ghanashyam Paudyal
Rosha Marahatta
Birendra Shrestha
Dr Bidur Ghimire

Promoting H&S in Nepal (Project):
Hari Nepal – Project Lead
Shailendra Kajee Shrestha
Raj Kumar Tripathi
Rajendra Kharel
Bibek Koirala
Mohammed Ansari

Membership: Dr Bidur Ghimire - Coordinator
Dr Roshan Bhattarai
Gopal Neupane
Akshaya Chapagain
Sagyan Kharel
Dilesh Lamsal

Young Engineers Mobilisation: Ms Pooja Bhagat - Coordinator

Sagyan Kharel
Ms Megha Paudyal
Ms Om Thapa
Ms Pooja Gurung,
Akshaya Chapagain,
Pawanman Bajracharya,
Bhupesh Mishra
Ms Samana Shrestha

Technical Conference & Seminar Organising: Dr Birendra Shrestha - Coordinator

Dr Ramesh Marasini
Krishna Kishor Shrestha
Prof Keshab Dahal
Narad Bhandari
Dr Hom Nath Dhakal
Dr Bidur Ghimire
Pooja Bhagat

Training Organising & CPD: Bed Prakash Bhattarai - Coordinator

Rashmi Singh Rana
Suraj Rai
Shankar Chaudhary
Dr. Bidur Khanal
Dr. Bidur Chapagai
Suryanath Ghimire

Social, Entertainment & AGM Organising: Pawan Man Bajracharya - Coordinator

Dr Roshan Bhattarai
Hari Nepal
Subhash Shrestha

Finance: Akshaya Chapagain - Coordinator

Fundraising & Charity: Shailendra Kajee Shrestha - Coordinator

Rajendra Kharel
Akshaya Chapagain

Constitutional Amendment & ToR Development: Umesh Parajuli – Coordinator

Debendra Dahal
Krishna Kishor Shrestha
Tara Lamsal
Yam Bhandar

Historic Members (since 2007)

Ambika Dhakal
Amod Jha
Anajana Shrestha
Anajani Phuyal
Ananta Devkota
Anjani Phuyal
Ashish Shrestha
Atma Khanal
Atma Ram Khanal

Bharat Bastola
Bhoj Raj Sharma (Kumar)
Bideh Mani Upadhyaya
Binay Neupane
Binod Adhikari
Bishnu Neupane
Bishnu Sharma

Chandra Kant Raut
Chandra Shrestha
Chintan Poudel

Damber Subedi
Deepak Gajurel
Dhanrupa Gurung
Dhruba Kumar Shrestha
Dhruba Sharma
Dinesh Dhungel
Dinesh Tuladhar
Diwas Bhattarai
Diwas Shrestha
Durga Goutam
Durga Khanal
Durlav Khanal

Gaurav Parajuli
Geeta Lamsal
Gopi Shrestha
Gyanendra Lal Shrestha

Hemanta Pandey

Jeevan Shrestha
Jiban Bajracharya
Jyoti Mishra
Jyotindra Gurung

Kamal Bhaila
Kedar Pant
Keshav Rajauria
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Khem Limbu
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Krishna Neaupane
Kul Prasad Marahatta

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Madan Sharma
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Manoj Shrestha
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Namu Chaulagain
Narendra Shrestha
Neeta Poudel
Nir Lal Moktan
Nirvan Shrestha
Nriprendra Shakya

Ojesh Singh
Om Krishna Shrestha

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Padma Amatya
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Pravin Karki
Punya Prasad Regmi
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Purushotam Subedi
Purusotam Kaphle
Purusotam Shakya

Rabin Giri
Rabindra Nayaju
Rachana Shrestha
Radha Adhikari Neaupane
Raj Kapur Shah
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Ram Chandra Pandey
Ram Kumar Shrestha
Ram Kumar Shrestha
Ram Poudel
Ram Raj Sharma
Ramesh Gurung
Ramhari Poudyal
Ramji Pahari
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Ranjan Baral
Ranjita Singh Malla
Rhijuta Dahal
Ritesh Bhattarai
Roshan Lovely Shrestha
Rudra Koirala

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Sanam Pokhrel
Sanjay Das
Santosh Kumar Pun
Seema Libmu
Shalu Agrawal
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Snagat Tamang
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Sudarsan Sharma
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Sundar Lama
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Top Lal Kandel
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Yasmine Bhattarai
Yog Raj Poudel
Yogya Gurung

Ashmi Jewellers
UK

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Krishna Kumar Shrestha
Director

k_k_stha@hotmail.com

ashmijewellersuk

United Kingdom

Unit 4 256-261 Northolt Road
South Harrow, HA2 8HS
London, UK

07411680497
+442036896428

Nepal

Kathmandu 44600,
Nepal

+977 9810139630
+977 01 4224905

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it is an honour to support SONE (UK)'s initiative towards an

innovative and flourishing Nepal.

As a member, I would like to convey my best wishes for their future endeavours.

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& Associates