# 14th ASNEngr Annual Conference: "Fostering technology development for shared benefits"

**Date:** August 14 -15, 2021 **Time:** 9:00 AM to 2:30 PM ET
**Venue:** Online via Zoom and Live Streaming on Facebook
Zoom link provided to registered attendees for live interaction and PDH certificate
Facebook: https://www.facebook.com/ASNEngr

On behalf of the Conference Organizing Committee, we would like to welcome you to the 14th American Society of Nepalese Engineers (ASNEngr) Annual Conference. The society has a broader membership, which is also reflected in our conference with the attendees participating from multiple fields of engineering and scientific community. With a theme of "Fostering technology development for shared benefits", we have expanded the program this year with a conference theme speech and a motivational talk in addition to invited speeches, technical sessions and panel discussions. Despite the technical content, we have encouraged presenters to explain the significance of their work in general terms so that non- technical folks can also understand and remain engaged. To make the presentations more interactive, we have quizzes for the audience after the presentations for an opportunity to win prizes.

With these highlights, we would like to express our heartfelt gratitude to all invited guests, reviewers, presenters, sponsors and attendees. Special thanks to the members of the Conference Steering Committee, Conference Technical Committee, Fundraising and Outreach Committees, and Board of Directors for making this conference happen. We wish you all an enriching and memorable conference.

Ananda M Paudel, PhD, PMP
General Chair

Suroj Lamichhane
General Co-Chair

Nipesh Pradhananga, PhD, PE
Technical Chair

Shubha Adhikari, AICP
Technical Co-chair

## Conference Schedule At-A-Glance

**Saturday, August 14, 9:00 AM – 2:30 PM ET**

| | |
|---|---|
| 9:00 AM – 9:10 AM | Conference Opening |
| 9:10 AM – 9:30 AM | Guest Speaker |
| 9:30 AM – 9:50 AM | Conference Theme Speech |
| 9:50 AM – 10:00 AM | Break |
| 10:00 AM – 10:30 AM | Keynote Speaker |
| 10:30 AM – 11:10 AM | Plenary Session |
| 11:10 AM – 11:40 AM | **Panel Discussion:** ASNEngr's Activities |
| 11:40 AM – 12:10 AM | Break |
| 12:10 PM – 1:15 PM | **Technical Session I:** Planning, Sustainability, and Environment |
| 1:15 PM – 1:25 PM | Break |
| 1:25 PM – 2:30 PM | **Technical Session II:** Transportation Infrastructure |

**Sunday, August 15, 9:00 AM – 2:30 PM ET**

| | |
|---|---|
| 9:00 AM – 9:30 AM | Conference Opening and Motivational Speaker |
| 9:30 AM – 10:35 AM | **Technical Session III:** Emerging Technologies |
| 10:35 AM – 10:45 PM | Break |
| 10:45 AM – 11:45 AM | **Technical Session IV:** Physical Environment and Human Interactions |
| 11:45 AM – 12:25 PM | Break |
| 12:25 PM – 1:55 PM | **Panel Discussion:** Engineering Pathways |
| 1:55 PM – 2:00 PM | Awards and Conference Closing Remarks |
| 2:00 PM – 2:30 PM | Virtual Networking |

## Invited Guests/ Speakers

**Dr. Yuba Raj Khatiwada**
Nepali Ambassador to the United States of America
Washington, D.C.

Prior to becoming the Ambassador, Dr. Khatiwadahe was the Minister for Finance and Information and Communications. He brings extensive experiences of having served two tenures as the Vice Chairman of the National Planning Commission in addition to becoming the 15th Governor of Nepal Rastra Bank, the Central Bank of Nepal. He also served as a senior economist at the regional center of the United Nations Development Program (UNDP) for Asia and the Pacific.

**Mr. Sanyukta Shrestha**
President, Society of Nepalese Engineers in UK (SONE UK), London, UK.

Mr. Shrestha has an engineering degree from Nepal Engineering College and graduated from London Metropolitan University in 2006. He is associated with many organizations such as Computer Engineer's Association of Nepal (Founding Executive, 2004), Pasa Puchah Guthi UK London (President, 2018-2020) and Society of Nepalese Engineers in UK (Chairperson, 2020).

**Dr. Tri Ratna Bajracharya**
President, Nepal Engineers' Association (NEA)

Dr. Bajracharya is a Mechanical Engineering Professor and has also served as the Dean of Institute of Engineering and Director of the Center of Energy Studies. He has contributed to the field of renewable energy technology and is one of the experts in the field of energy and climate change. He has published a number of research papers in international journals. He is also the Chief Editor of Journal of the Institute of Engineering.

**Dr. Bhola Thapa**
Vice Chancellor, Kathmandu University, Kathmandu, Nepal

Mechanical Engineer by trade, Dr. Thapa has led the project implementation team of KOICA in establishing the Technical Training Center. He established the South Asia Subregional Economic Cooperation (SASEC) ICT Research and Training Network in support of ADB, started Turbine Testing Laboratory at Kathmandu University with support from NORAD, and also spearheaded the establishment of "RenewableNepal" research program. Prior to becoming VC, Dr. Thapa served as Registrar and Dean of School of Engineering at Kathmandu University.

**Dr. Mani GovindaSamy TamizhMani**
Director, Photovoltaic Reliability Laboratory (PRL), Arizona State University, AZ USA

Dr. Mani is the founder and director of Photovoltaic Reliability Laboratory (PRL) at Arizona State University and the founder and President of SolarPTL (SolarPTL.com). ASU-PRL has supported more than 100 master and Ph.D. graduates over the years researching lifetime prediction of solar PV modules. Dr. Mani was the former director of ASU-PTL, the first accredited PV certification lab in the United States. He has published more than 180 papers in peer-reviewed journals and conferences and delivered more than 160 presentations. He obtained his Ph.D. degree from the Indian Institute of Technology, Bombay, and his postdoctoral training in France and Canada.

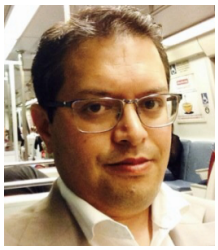
**Ambika Adhikari, D.Eng, AICP**
Principal Planner, City of Tempe, AZ

Dr. Adhikari is a Principal Planner managing the long-range planning division at the City of Tempe, AZ. He has authored multiple books and refereed articles on sustainability and urban planning, international development, climate change policy, and international environmental policies and programs. He has served in several countries including Nepal, India, the USA, Canada, Mexico, Kenya, and Fiji. A certified planner, Dr. Adhikari is also very active in ASNEngr and other social organizations.

**Mr. Anil Chitrakar**
Motivational Speaker

Mr. Anil Chitrakar, a social entrepreneur and motivational speaker, is the President of Siddharth Inc, an initiative dedicated to innovate and scale engineering solutions responsibly ensuring a long-term positive impact on society. Mr. Chitraker has traveled to rural Nepal and installed/transferred renewable energy technologies as an energy engineer of the Academy of Science and Technology. He is an Ashoka Fellow, recognized for his work in enabling school children to be the agents of change in conserving and managing Nepal's natural, cultural, and built heritage.

**Mr. Pravin Karki**
Lead, Global Hydropower & Dams Program, World Bank



Mr. Karki leads the Global Hydropower & Dams Program in the World Bank. He has led a team of experts to develop climate change resilience guidelines and authored a book on Extending the Life of Reservoirs. He has worked on hydropower projects in Africa, Central-South-East-Asia, and the Pacific. Pravin, a civil engineer by trade, who joined the World Bank in 2007 after completing a Master of Philosophy at the University of Cambridge, is from Dharan, Nepal.

**Dr. Upendra Karna, PE**
Owner, U&S Engineers

Dr. Karna is the owner of U&S Engineers, a structural and geotechnical engineering service provider. He has over 32 years of experience in his area of expertise. He has published several technical articles and presented at national (USA) and international professional organizations and conferences. He has been involved with ASNEngr since its inception, and is a fellow life member and the Immediate Past President. Dr. Karna is leading ASNEngr's position paper on the flood conditions in Nepal.

**Dr. Dinesh Kumar Sharma**
Professor, Institute of Engineering, Pulchowk Campus.

He has led the Subject Committee, IOE Entrance Committee and served as Assistant Dean of IOE and Director of the Centre for Information Technology, Pulchowk Campus. Professionally, he has served as a Chairman of Nepal Telecommunications Authority. His expertise is in Communications Systems Engineering and contribution in Solar Photovoltaics electronics are commendable. Dr. Sharma is one of the pioneers in engineering education in Nepal and a popular faculty.

# Detail Program, Saturday, August 14, 2021

**9:00 AM - 9:10 AM Conference Opening**

**Ananda Paudel, PhD**, General Chair
Welcome and Conference Overview

**Thakur Dhakal, PE**, President, ASNEngr
Welcome and Society's Overview

**9:10 AM – 9:30 AM Guest Speakers**

Session Chair: **Thakur Dhakal, PE**

**Dr. Yuba Raj Khatiwada,** Nepali Ambassador to the United States of America Washington, D.C.

**Dr. Tri Ratna Bajracharya**, President, Nepal Engineers' Association (NEA)

**Mr. Sanyukta Shrestha,** President, Society of Nepalese Engineers in UK (SONE UK), London, UK

**9:30 AM – 9:50 AM Conference Theme Speech**

Session Chair: **Ananda Paudel, PhD**

Fostering Technology Development for Shared Benefits, **Dr. Bhola Thapa,** Vice Chancellor, Kathmandu University

**Break 9:50 AM – 10:00 AM**

**10:00 AM – 10:30 AM Keynote Address**

Session Chair: **Dr. Rajendra Shrestha**

Solar Photovoltaics: Market, Technologies, Reliability and Certification, **Dr. Mani GovindaSamy TamizhMani,** Professor**,** Arizona State University

**10:30 AM – 11:10 AM Plenary Session**

Session Chairs: Dr. **Prakash Kaini, P.E** and Dr. **Manoj Karkee**

Climate Challenge and Hydropower in Nepal: Myth or Reality, **Pravin Karki,** Lead, Global Hydropower & Dams Program, World Bank

Understanding of Flood Disaster Conditions and Recovery in Nepal, **Dr. Upendra Karna, PE**

**11:10 – 11:40 - Panel Discussion: ASNEngr's Activities**

ASNEngr Officers: **Narayan Pokharel, PEng**
**Shyam Sharma, PhD, PE**
**Jagannath Ghimire, PE**
Invited from Pulchowk Campus:
**Indra Parajuli PhD**, Campus Chief
**Basanta Joshi**,**PhD**, Head, Electronics Department

**Break 11:40 AM – 12:10 AM**

**12:10 – 1:15 PM Technical Session I Planning, Sustainability and Environment**

Session Chairs: **Kamal Gautam, PhD, PE** and **Om Dhodary, PE**

Towards Creating Smart and Sustainable Cities in Nepal**, Dr. Ambika P. Adhikari, AICP** *(Invited Speaker)*

Advancing Urban Resilience through Local Area Planning, **Upendra Sapkota, AICP**

Developing Mobile Wind Energy Unit for Supplying Power for Hurricane Affected Community,
**Rabin Dhakal*, Siva Parameswaran, and Hanna Moussa**

Development of a Low-Cost Aerial Research Platform for Hyper-Local Air Pollution Mapping in Nepal, **Prateek Man Shrestha, Sudip Bhattrai, Rakesh Chandra Prajapati**

**Break 1:15 AM – 1:25 AM**

**1:25 – 2:30 PM Technical Session II Transportation Infrastructure**

Session Chair: **Pusker Regmi, PhD, PE** and **Salil Devkota**

An Overview of Transportation System Modelling, **Birat Pandey, PE**

A Study of NM 500 Bridge for the Use of SRH-2D Hydraulic Model to Develop "NO RISE" Documentation for Project in FEMA Regulatory Floodway, **Govinda Karki, PhD, PE**

Development of Non-Proprietary Ultra High Performance Concrete, **Bijaya Rai***

An Enhanced Framework to Compute Road User Costs, **Jeremiah Adebiyi*, K. Joseph Shrestha, Moin Uddin**

# Detail Program, Sunday, August 15, 2021

**9:00 AM – 9:30 AM Conference Opening and Motivational Speaker**

Session Chair: **Ramesh B. Malla, PhD, F ASCE, F ASNEngr**

Greetings from Society of Neplease Student in Korea (SONSIK), **Ravi Ghimire**

The Aspirational Engineer in Nepal - What to Expect in the Next Decade, **Anil Chitrakar**

**9:30 AM – 10:35 AM Technical Session III Emerging Technologies**

Session Chairs: **Samana Ghimire** and **Kiran Adhikary, PE**

Engineering Education in Nepal and ASNEngr's Role, **Dr. Dinesh K. Sharma** *(Invited Speaker)*

Beyond Bitcoin: Decentralizing Trust at an Industrial Scale in Transportation and Supply Chain using Blockchain Technology, **Rajat Rajbhandari, PhD**

Drones: The Future of Bridge Inspection, **Utsab Pokharel**

Incompatible Graded Finite Elements Used for Thermal Stress Analyses, **Sukirti Dhital*, Jeongho Kim**

**Break 10:35 AM – 10:45 AM**

**10:45 AM – 11:45 AM Technical Session IV Physical Environment and Human Interactions**

Session Chairs: **Prakash Malla, PhD, F ASNEngr** and **Sudha Bhusal, PE**

A Science of Human Society with Two Eyes Open, **Ram Poudel, PhD**

The Architecture of Hope - "Cancer Care Center", **Upama Khadka***

Design and construction of housing for flood-prone rural areas of Terai, **Shraddha Adhikari**

Design of Affordable and Practical Wheelchair Booster Module, **Smirti Pokhrel*, Armoghan Shaheen**

**Break 11:45 AM – 12:25 PM**

**12:25 PM – 1:55 PM Panel Discussion: Engineering Pathways**

Moderators: **Sarmin Ghimire** and **Surya Thapa, PE**

Panelists:
**Binod Tiwari, PhD, PE**
**Bishal Khadka**
**Janak Thapa, PE**
**Pratistha Pradhan, PhD, PE**
**Rabin Dhakal**
**Raju Joshee**

**1:55 PM – 2:00 PM Awards and Conference Closing Remarks**

Session Chairs: **Thakur Dhakal, PE** and **Ananda Paudel, PhD**

**2:00 PM – 2:35 PM Virtual Networking**

Session Chairs: **Thakur Dhakal, PE** and **Mangal Maharjan**

* *indicates student presenters*

## Conference Steering and Technical Committee

Ajaya Dhakal
Ananda Paudel, PhD
Ananta Baidya, PE
Bishal Khadka
Bishnu Phuyal
Deb Jaisi, PhD
Deependra Pokharel
Govinda Karki, PhD, PE
Jiwan Ninglekhu, PhD
K. Joseph Shrestha, PhD
Kanhaiya Kayastha, PE, SE, F ASNEngr
Kaushal Jha, PhD
Kishor Shrestha, PhD, PE, M ASCE, LEED GA
Krishna Kisi, PhD, PE
Krishna Mani Lamichhane, PhD
Kul Mani Acharya
Madan Baral, PE, PMP
Mangal D. Maharjan
Manoj Karkee, PhD
Narayan Pokhrel, Peng
Nipesh Pradhananga , PhD, PE
Om Dahal, PhD
Pradeep Khanal
Prahlad Pant, PhD, PE
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Purna Dahal, PE
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Srijana Khatiwada Sharma, MS CS
Sukh Gurung, PhD, PE
Surya Thapa, PE
Thakur Dhakal, PE
Upendra L. Karna, D Eng, PE, F ASNEngr

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## Other Contributors

Om Dahal, PhD, Quiz Master
Madan Baral, PMP, Zoom hosting
Bishnu Phuyal, PhD Outreach Activities
Sujan Subedi, Vice-chair, Student Committee
Sailesh Pokharel, BRTNepal, CO
eNepalese News, DC
MahaLaxmi Thapa, ML Online, FL
Kusum Gaywali, Canada
Udeep Pokharel, CO
Aaditya Acharya, CO
Bhishma Kumar Chhetri, Australia
Bed P Bhattarai, United Kingdom

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**American Society of Nepalese Engineers (ASNEngr)** - a non-profit organization established in September 2007 with IRS 501(c)(3) tax exempt status – aims at providing a common platform for people of Nepalese background and their friends, in engineering and closely related scientific and technical areas to come together, exchange ideas, and support each other for their and the larger society's common good and benefits. It operates for engineering, scientific and technological research and educational purposes. The Society also strives at promoting engineering, scientific, and technological advancement in Nepal. The Membership application form and detailed information on ASNEngr and updates on its recent activities can be found at http://www.ASNEngr.org.

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*For more information on the conference, please visit:* www.ASNEngr.org

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## Abstracts

# Solar Photovoltaics: Market, Technologies, Reliability and Certification

**Dr. Mani GovindaSamy TamizhMani**
Director, Photovoltaic Reliability Laboratory, Arizona State University, AZ USA

## ABSTRACT

Solar photovoltaic (PV) technologies convert sunlight into electrical energy. The amount of sunlight that strikes the earth in less than 2 hours is more than enough to support the entire world's energy consumption for a full year.

In this presentation, the following topics will be covered: market potential in Nepal and current/future levelized cost of energy (LCOE) in the United States; differences between various solar technologies and systems including grid-tied and stand-alone PV systems; past and present PV module technologies including BSF and PERC technologies; indoor and outdoor performance measurements using solar simulators and natural sunlight; durability and reliability issues in various climatic conditions; the safety and quality certification requirements at the national and international levels to ensure that the installed solar panels are safe and reliable in the field over the years and decades.

# Understanding of Flood Disaster Conditions and recovery in Nepal

**Dr. Upendra L Karna, P.E.**
Past President and Chair of Flood Position Paper, ASNEngr

## ABSTRACT

Most of Nepal is overlain by a very young mountain range called "Himalaya". It is one of the most active and fragile mountain ranges in the world. A combination of naturally developed rough topography, steep slopes, active seismic effects and intense monsoon rain around the Himalayan area have made Nepal highly vulnerable to landslides, surface erosion and floods. Landslides and erosion developed along the weak surface resulting in significant amounts of sediments to the flooded rivers during the monsoon season create an enormous effect on property and life primarily in southern Nepal.

The source of flooding in the upper Himalaya is due to glacial lake outbursts. The flooding in Mahabharat hills area of Nepal is due to monsoon rain exacerbated by landslides and surface erosion. However, the flooding in the Siwalik/Chure hills and in the southern terai area is primarily due to heavy monsoon rains and the high content of sedimentations transported along by the overflowing rivers. The current flood situations have been worsened more due to unplanned and illegal developments within and along the floodplain area. Haphazard and poorly designed infrastructure developments, and environmental degradation in the hills have further worsened the condition. Flood is a natural disaster that occurs every year in Nepal. Flooding cannot be eliminated, but its impact on the properties and life can be controlled by implementing proper engineering, technology and planning.

ASNEngr is currently preparing a position paper on the flooding conditions in Nepal. This position paper will contain the understanding of past and current flood situations and policies in Nepal and suggestions will be made for the better management of flooding situations in Nepal. Flooding due to hill slides and urban flooding situations will also be addressed. This presentation will discuss the overall content and approach being considered by the position paper preparation committee. Additional personal thoughts and understanding on the flooding situations in Nepal and suggestions for better management will also be included in this presentation.

# Towards Creating Smart and Sustainable Cities in Nepal

**Dr. Ambika Prasad Adhikari, AICP**
Principal Planner, City of Tempe, AZ USA

## ABSTRACT

Globally, the rapid growth in urbanization is making dramatic impacts in the way people live, work and play. The unprecedented and speedy urban growth in Nepal has also brought about drastic changes in the urban living and quality of urban services.

The urban centers of the Kathmandu Valley – the capital region of Nepal – face several challenges related to the state of planning, infrastructure, mobility and the environment. As individual incomes have been rising, largely fueled by a remittance economy, people's standard of living and aspirations have also grown putting further strain on the Nepali urban system. While improvements can be seen in some areas such as construction quality, water supply and sanitation, the urban dwellers continue to face major challenges such as traffic congestion, pollution in all media, and loss of walkability, and deteriorating aesthetics in the public realm.

Many urban centers in the world are seeking to become smart cities to solve their day-to-day urban problems and to gain futuristic levels of efficiency. To manage the urban challenges and keep the constituency happy, Nepali city leaders also often speak about making their cities smart.

A smart city basically has three areas with clever improvements: technological, human, and institutional, often implemented through the "Internet of Things (IoT)". Many cities have recently made impressive enhancements in at least one or more of these areas. As most Nepali cities still operate with limited infrastructure, services, and amenities, making them smart is a challenging task. However, some elements of a smart city can be gradually and selectively implemented by the Nepali urban governments and partners. Two examples are rapid transit bus and a light rail system for the Kathmandu Valley consisting of electrical trolleys and buses. Such transit systems will drastically reduce air pollution and improve the efficiency of transportation.

Urban leaders in Nepal can begin to identify the most appropriate and relevant smart elements to be gradually implemented in their cities which will improve efficiency of urban services, enhance quality of life for the urban residents, and promote sustainability of the overall urban system.

# Advancing Urban Resilience through Local Area Planning

**Upendra Sapkota, AICP, LEED AP**
Sr. Office, Planning and Development at Fort Monmouth Economic Revitalization Authority, NJ USA

## ABSTRACT

In recent years, issues related to sustainability, disaster prevention, and urban resilience have occupied central space both in academia and non-academic sectors. The frequent re-occurrences of natural disasters and real-time information on their impacts on humanity have raised global awareness regarding sustainability measures, disaster prevention & management, and mitigation techniques. The adaptation of the Hyogo Declaration by the United Nations International Strategy for Disaster Risk Reduction (UNISDR) in 2005 has brought global attention to the importance of disaster resilience. Following the Hyogo Declaration, many countries, including the United States, formulated the national policy on disaster resilience (National Academies [U.S.], 2012). While there have been constant discussions to address issues related to climate change and disaster-resilient communities on the global level, the impact of local area planning and local initiatives towards advancing urban resilience or community resilience has not gotten enough attention.

With the increasing frequency of natural disasters in recent years and their immediate impact experienced at the local level, planners, policymakers, leaders, academics and professionals have already started taking several initiatives at the local level with the goal of building resilient communities as well as to aid the national strategies. With this background, the paper will highlight some of the local planning strategies, programs and initiatives that the City of Newark, New Jersey has taken in advancing urban resilience. It will also illustrate how such programs have been incorporated into the zoning and land use regulations. In conclusion, the paper will summarize the key initiatives and programs that can be replicated in other cities having similar geographic and social characteristics and facing similar challenges.

# Developing Mobile Wind Energy Unit for Supplying Power for Hurricane Affected Community

**Rabin Dhakal**
PhD Candidate, Department of Mechanical Engineering, Texas Tech University, TX USA

**Siva Parameswaran, PhD**
Professor, Department of Mechanical Engineering, Texas Tech University, TX USA

**Hanna Moussa, PhD**
Assistant Professor, Department of Mechanical Engineering, Texas Tech University, TX USA

## ABSTRACT

Hurricanes, also known as tropical cyclones, are storms with violent wind in coastal areas and are considered as hazards with major impacts on population centers. In the US, 164 million people - more than 50% of the total population live in densely populated coastal counties, which are also major centers of economic activity contributing 58% of the national gross domestic product (GDP). Hurricanes are also the major cause of power outages in the US as 9 of the 10 largest blackouts are due to hurricanes. According to weather forecasting centers, a hurricane affects the coastal region about three times every four years. As a result, every year, these coastal regions suffer from frequent power outages due to trees collapsing and knocking down power lines. The State of Texas has witnessed many hurricanes hitting the state and it is the second state most affected by hurricanes only behind Florida. After 1980, 81 tropical or subtropical cyclones were recorded that affected different counties in Texas. Recently, in April 2020, a tornado outbreak moved through Texas causing 4.3 million customers to lose power, affecting an estimated 9.3 million people for about 3 days. Hence, there arises a need for alternative thinking, i.e., mobile or in-situ stand-alone power generation for situations when conventional power supply systems, for e.g., national grid, fails to give a smooth transition. Therefore, it is now high time to develop mobile infrastructure to supply electricity in these extreme conditions. This will not only help be better prepared for such an event but also help to mitigate several problems that may arise due to blackouts. In the post hurricane situation, the use of renewable energy sources is not very common. Instead, generators that use fossil fuels are commonly used. One of the main reasons for the preference to the generators is that the generators of renewable energy sources are generally of static structure and cannot be transported easily in affected areas. Another reason is that renewable energy sources are not stable. However, this reason is not always valid in coastal areas especially in Texas as this area has high wind intensity. Hence, a small-scale wind turbine pre-installed or of mobile nature can be used to supply power to hurricanes affected communities, especially providing a small amount of power needed for basic services such as lighting, heating, and cooking. A small 4-bladed vertical wind turbine that can be mounted on a ground vehicle (4WD) is proposed for emergency use in hurricane affected areas. Because of the design of the blades, the mobile wind turbine can catch the wind easily in every direction and strength. Thus, energy generation will be possible even at variable intensity of wind flow that occurs in coastal hurricane affected communities. Moreover, the estimated cost of the proposed mobile wind turbine is similar to the standard static wind turbines.

# Development of a Low-Cost Aerial Research Platform for Hyper-Local Air Pollution Mapping in Nepal

**Prateek Man Shrestha**
Postdoctoral Research Associate, Oak Ridge National Laboratory, Oak Ridge, TN, USA

**Sudip Bhattrai**
Assistant Professor of Aerospace Engineering, Institute of Engineering, Pulchowk Campus, Lalitpur, Nepal

**Rakesh Chandra Prajapati**
Test Engineer, ALTEN Switzerland AG and Founder/CEO, Orion Space Pvt. Ltd. Madhyapur Thimi, Nepal

## ABSTRACT

There is limited data on hyper-local mapping of air pollution in the urban area of Nepal. This project aims at developing a portable aerial research platform for providing on-site hyper-local air pollution data of urban areas of Nepal using a custom-built air monitoring instrumentation integrated with a locally developed quadcopter drone. The air monitoring instrumentation consists of an Arduino board integrating an array of low-cost air sensors for monitoring air pollutants: $NO_2$, $SO_2$, $O_3$, $PM_{2.5}$, and atmospheric temperature, barometric pressure, and relative humidity of the monitoring site. Variants of a locally developed quadcopter drone, which is an unmanned aircraft system (UAS), made of polymer frames, with wheelbase of 600 mm and payload capacity of up to 3 kg, will be deployed as the aerial monitoring platform. The UAS can be operated manually and can be programmed to take autonomous flights. The platform can be powered by a single Li-Po battery, which also supplies power to the air monitoring instrumentation through a battery eliminator circuit. This aerial platform will help academics and researchers to collect atmospheric air pollution data by positioning the platform at any desired location even for short durations, within the limits of regulated airspace and telemetry range. Air pollution data captured at the desired locations will help in developing hyper-local three-dimensional air pollution mapping that can be used for establishing air pollution management and mitigation strategies. The technical aspects of the aerial platform development process will be discussed along with the challenges, and its potential future use.

# An Overview of Transportation System Modelling

**Birat Pandey, PE**
Freight Analysis and Data Program Manager, Federal Highway Administration, Washington DC, USA

## ABSTRACT

Sharing of research, education and practice related knowledge and experience is one of the goals of the American Society of Nepalese Engineers (ASNEngr). In line with this goal, this presentation will focus on providing general information about transportation system modeling and context about forecasting tool applications in transportation planning, program development and policy evaluations. Considering other matured fields of engineering, transportation modelling is a relatively new discipline. It evolved from the urban transportation studies of the 1950s in the U.S. The objective of this presentation is to outreach to ASNEngr members to share information and enhance knowledge about the current approach of considering future travel demand into transportation plans and programs development activities.

# A study of NM 500 Bridge for the use of SRH-2D hydraulic model to develop "NO RISE" documentation for project in FEMA regulatory floodway

**Govinda Karki, PhD, PE**
Drainage Engineer, WSP, Santa Fe, NM USA

## ABSTRACT

State agencies historically considered themselves to be exempt from Federal Emergency Management Administration (FEMA) regulations since these were enforced by local jurisdictions. This perception was challenged in 2019 when FEMA notified governors throughout the nation that states were not exempt and required them to describe how they were (or weren't) following floodplain regulations and what their plan was going forward to ensure future compliance. Concerned departments in every state are leading the effort to bring state agencies into compliance.

The existing FEMA effective hydraulic model for NM 500 (Rio Bravo Boulevard), which crosses the Rio Grande in Albuquerque, was developed in 1982 using the HEC-2 computer program. FEMA designated the project location as zone "AE" with regulatory floodway, meaning the channel of a river must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height. Flood Insurance Study (FIS) for the project area was updated in 2016 with the same HEC-2 result by adjusting the vertical datum to North American Vertical Datum of 1988 (NAVD88). When crossing FEMA regulatory FLOODWAYS, it is contingent upon the development agency to make sure there is "NO-RISE" in base flood elevation (BFE). No-rise is a measurement of the change in BFE or 100-year water surface elevation, as measured to the nearest 0.00 feet, created by proposed development. If no-rise is not achievable, then the development agency (New Mexico Department of Transportation or NMDOT) must go through the Letter of Map Change (LOMC) process, which is not desirable due to constraints in time and resources. Both no-rise certification and LOMC processes require simple to detailed hydraulic analysis. More robust hydraulic analysis tools are available now than there were in the 80's, and we performed the hydraulic analysis for the NM 500 project using Sediment and River Hydraulics (SRH-2D). The result for the corrected effective model, using SRH-2D, showed slight variation in BFE against FEMA effective model (HEC-2). This presentation will cover the process of creating a corrective effective model in SRH-2D and comparing its results with an older existing model provided by FEMA.

# Development of Non-Proprietary Ultra High Performance Concrete

Bijaya Rai,
University of Connecticut, CT USA

## ABSTRACT

Ultra-high performance concrete (UHPC) is being seen as the most innovative and impactful development in the field of construction materials. It uses a relatively high amount of binder, usually has a water to cementitious ratio of less than 0.2, shows a compressive strength in excess of 150 MPa (22 ksi), and is characterized by superior durability properties compared to conventional concrete. The addition of tailored discontinuous fibers leads to significantly higher ductility and durability of the cracked matrix. Its key property is a dense and low permeable concrete matrix [1]. This provides excellent resistance against chlorides, sulfates, and other aggressors. Use of UHPC reduces the cross section of structural members as we can get the higher mechanical properties with smaller cross sections than using conventional concrete. The UHPC has been extensively used in European countries, yet it isn't widespread in the rest of the world.

Current drawbacks in the wide-spread use of UHPC are the high material cost and the proprietary nature of commercially available products [2].

Typical Ingredients:

| Ingredients | Constituents | Size |
|---|---|---|
| Cement | Moderate Fineness, Low $C_3A$, High $C_3S + C_2S$ | 10-20µm |
| Silica Fume | Low Carbon Content | 0.2-1µm |
| Silica Powder | Silicon Dioxide ($SiO_2$) | Median size (1.7µm) |
| Silica Sand | Higher quality w/ high strength & low water absorption | |
| Superplasticizer | High Range Water Reducer | |
| Fiber | Steel Fiber | 13mm long / 0.2mm ø |

Use of white cement, silica powder, and finely refined silica sand produces highly expensive UHPC. In this research, we use following approaches to make UHPC economical, yet providing similar mechanical and durability properties:

i) Use of locally available materials i.e. transportation of material from one part of the world to another costs a lot.
ii) Replacing the finely refined silica sand with locally available aggregates
iii) Removing silica powder from the matrix
iv) Replacing the portion of silica fume by cement
v) Use of type II/V cement instead of white cement

References:

1. Wille, K., Naaman, A.E, Parra-Montesinos, G. J, "Ultra-High Performance Concrete with Compressive Strength Exceeding 150 Mpa (22 Ksi): A Simpler Way", ACI Materials Journal, Vol. 108-1, 2011.
2. Wille, K., Boisvert-Cotulio, C. "Material Efficiency in the Design of Ultra-High Performance Concrete", Elsevier – Construction and Building Material, Vol. 86, 2015, pp. 33 – 43.

# An Enhanced Framework to Compute Road User Costs

**Jeremiah Adebiyi**
Graduate Research Assistant, East Tennessee State University, TN USA

**K. Joseph Shrestha, PhD**
Assistant Professor, East Tennessee State University, TN USA

**M. Moin Uddin, PhD PE**
Associate Professor, East Tennessee State University, TN USA

## ABSTRACT

The construction and maintenance of essential transportation facilities such as bridges and roadways cause inconvenience to the road users. Such inconveniences were traditionally not considered while making project management decisions, such as selecting the best contractor for the project. However, state Departments of Transportation (DOTs) have started to consider such road user inconveniences by quantifying the monetary impact as the Road User Costs (RUCs). While the Federal Highway Administration (FHWA) has provided a detailed methodology for computing the RUCs, implementing the methodology requires a significant amount of time, effort, and data. Many state DOTs representatives may not have sufficient resources to compute such detailed RUCs. As such, some state DOTs have developed oversimplified state-specific methodologies to compute RUCs that may result in inaccurate accounting of the RUCs. Thus, there is a need to develop an enhanced framework to compute RUCs that balances the effort required and the accuracy of the result.

This study conducted an extensive review of existing literature, conducted a nationwide survey to identify the current practices of computing RUCs, and developed an enhanced framework to compute RUCs that balances the effort required and the accuracy of the results. The study found that 34 out of 37 state DOTs that responded to the survey are computing and utilizing the RUCs. The major components of the RUCs are Delay Cost (DC), Vehicle Operating Cost (VOC), Crash Cost (CC), Emission Cost (EC), and Local and Business Impact Cost (LBIC). The DC and VOC are two components that are most widely accounted for in various state DOT methodologies. In comparison, the enhanced methodology accounts for four components - DC, VOC, CC, and EC. The major enhancements of the proposed framework include a) accounting for the spatial variation of the RUCs using location indexes, b) accounting for the temporal variation of the RUCs using an inflation index, and c) requiring minimal time, effort, and data to compute RUCs while accounting for most of the impacts.

A case study was conducted to demonstrate the use of the enhanced framework, and a spreadsheet-based tool was developed to ease RUC computation. Using the enhanced framework and the spreadsheet-based tool will enable state DOTs to easily and accurately compute RUCs to make better project-management decisions such as selecting the best contractor for a construction project and developing traffic management plans to reduce impacts on the road users.

# Beyond Bitcoin: Decentralizing Trust at an Industrial Scale in Transportation and Supply Chain using Blockchain Technology

**Rajat Rajbhandari, PhD**
Co-founder, dexFreight and Working Group Lead at MOBI, Dallas, TX USA

## ABSTRACT

One of the key byproducts of Bitcoin's introduction as a cryptocurrency in 2010, was an emergence of underlying technology called Blockchain. It is now heralded as one of the transformative technologies of our time with implications in finance, supply chain, insurance, governance, and transportation. Blockchain is a new kind of transactional ledger that is equally accessible to its participants and tamper evident. It is an open-source technology, which henceforth has allowed innovation at an exponential level globally. Blockchain decentralizes trust which is 35% of the cost in any economic transaction and constitutes 5% of our GDP. It reduces the cost of maintaining trust and when scaled it will create net new revenue potentials.

In transportation, it has already been applied in making supply chain and logistics more transparent and efficient. Public agencies, auto manufacturers, suppliers, mobility service providers are exploring ways to solve the age old problem of decentralizing trust and scale it at an industrial level to collaborate for better shipment provenance, emissions tracking, ethical sourcing of material etc. Although the technology is at its infancy, we've already seen early promises.

# Drones: The Future of Bridge Inspection

**Utsab Pokharel, EIT**
Assistant Engineer, New Jersey Department of Transportation, NJ USA

## ABSTRACT

Unmanned Aerial Vehicles (UAV) used to capture still images and videos by remote operation from ground are known as drones. Drones can capture the images in the location where in-person photography can be both challenging and demanding. Use of drones in bridge inspection not only reduces the cost of bridge inspection but also improves the safety of the bridge inspectors. It can improve the safety of the public as well as ensures uninterrupted flow of traffic as lane closures are not necessary.

According to the Federal Highway Administration (FHWA) there are over 610,000 highway bridges in the USA. Federal transportation agencies State Departments of Transportation, counties, and municipalities are the owners of major bridges within their jurisdictions. For the Federal, States or local governments it is challenging to collect and record the structural defects in different structural members of the bridges. The safety equipment for accessing different structural members of the bridge to inspect defects includes use of crash attenuator trucks for lane/shoulder closures of highway, lift trucks, snooper trucks for under bridge inspection, ladders, boats, ropes etc. Use of drones can replace these equipment whenever hands-on inspection is not required, thus, ensuring the safety of the inspection personnel.

Drones that can be used for bridge inspection costs between $500 to $10,000 depending upon the function and type of drone. Some drones can even prepare 3-D models of the structural members producing images of exact location and extent of the defects. Heavy equipment such as snooper trucks costs between $200,000 to $500,000 and requires a very large crew to operate. In New Jersey, McClain & Co., Inc. provides a 60 ft. snooper truck with lane/shoulder closure and crew for $6,975/day. Also, snooper trucks have a risk of being tipped over. According to an AASHTO special report, to compare cost, Michigan Department of Transportation (MDOT) conducted a survey using manual and drone inspection for 4-lane divided Highway Bridges in a Metro Area. Manual inspection used 2-person crew, heavy equipment, and 8 hours of work costing $4,600 whereas drone inspection needed 2-person crew, a drone and just 1 hour to complete the same inspection work costing $1,200 with 74% savings.

The Federation Aviation Administration (FAA) regulates drone activities. To operate a drone, the FAA Part 107 exam must be taken in-person for obtaining a commercial drone operation license. The operation license costs $175 with validity of 2 years and drone registration cost is $5 with validity of 3 years. Drones weighing less than 250 grams do not require licensing and registration. Some FAA regulations include restriction of flight above 400 feet and beyond 2 miles radius from an airport and drones must always remain in visual line of sight. North Carolina Department of Transportation (NCDOT) is the only state DOT that has been awarded a waiver by the FAA that allows drones to operate beyond visual lines of sight for bridge inspection. With field-based experience and practice, it appears that use of drones is the future for bridge inspection.

# Incompatible Graded Finite Elements Used for Thermal Stress Analyses

**Sukirti Dhital**
Graduate Research Assistant, University of Connecticut, CT USA

**Jeongho Kim, PhD**
Associate Professor, University of Connecticut, CT USA

## ABSTRACT

Functionally graded materials are multi-component composite that show compositional gradients from one component to other. This smooth transition from one material to another may reduce thermal and residual stresses as well as stress concentration factors. Owing to this, these materials have found a wide usage in high temperature applications. This research aims to capture the stress profile in functionally graded material subjected to thermal load using Finite Element Analysis (FEA). For this accurate and efficient thermal stress analysis is carried out in two-dimensional graded plates, using incompatible elements and the adopted approach is verified by comparing it against literature data. ABAQUS is used as FEA software and gradation in material properties is captured through user-defined subroutines (codes), UMATHT and UMAT. UMATHT captures the variation in thermal properties whereas UMAT is used for mechanical properties. All the analyses are carried out using three types of elements, linear-four node Q4 elements, six-node QM6 elements and quadratic eight-node Q8 elements. An emphasis is made on an incompatible six-node graded finite element (QM6) which is accurate and efficient compared to Q4 and Q8 elements. Accuracy of the elements is quantified with the help of posterior error estimation and efficiency is determined from the computational time. Modified 6-node (QM6) incompatible graded elements provide better accuracy than Q4 elements and take less computational time than Q8 elements, thereby showing QM6 as an optimal element for engineering analysis.

# A SCIENCE OF HUMAN SOCIETY WITH TWO EYES OPEN

**Ram Poudel, PhD**
Assistant Professor, Appalachian State University, Boone, NC USA

## ABSTRACT

Human society is an open system that evolves by coupling various known and unknown fluxes. How does this complex system dynamics precisely unfold? The science of human society may provide further insights. The evolution of our civilization has depended largely on cooperation among human beings. However, our science is yet to figure out 'How did cooperative behavior evolve?' This question [1] from the 'What don't we know' series from the Science journal has been awaiting physical reasoning for a long time. We generalize the classical field theories for an ensemble of human beings and propose the social field theory [2]. The social field theory formalizes the social force and the Hamiltonian of an individual in the social field. We underpin this new Hamiltonian as a physical basis for cooperation among human beings and the evolution of human society. With the Hamiltonian defined [3], we use the Navier-Stokes' approach to study the dynamics in the social field that evolves with time. The equations for the evolution of an individual and human society are sketched based on the time-dependent Hamiltonian that includes the power dynamics. Lotka-Volterra type equations can be derived from the Hamiltonian equation.

A fundamental understanding of why cooperation evolved may have a resounding effect on our understanding of social, political, and economic rationale. Indeed, Darwin uncovered some ideas of cooperation in his theory of evolution. However, the science of evolution doesn't provide physical reasoning, and is also not adequate for 21st-century human knowledge. Biologists are refining Darwin's ideas bit by bit. Here, we aspire to uncover the science of cooperation and many social dynamics in terms of the Hamilton of an individual in the social field. Human cooperation is not much different literally from cooperation that takes place between an electron and nucleons in a model of the Hydrogen atom. It is our consciousness that makes human cooperation special among social beings.

We speculate on some possible directions in which the science of human society may develop over the next few decades, especially by connecting the natural and social sciences -- the two eyes of our human knowledge. Money is a concept of paramount significance to economic science, social science in general. This new framework conceives of money following the original insights of Howard Odum [4]: money flows in circles, but energy flows through a system and ultimately comes out in a degraded form. These concepts may bring forth a useful connection between the sciences at the fundamental level. Even if the field-based approach based on homology may supply important insights to the core economic concept such as capital, development, business cycles, etc., there are still many important questions at the intersection of the two cultures [5] to which we currently have no satisfactory answers. We believe that a two-eyed approach may inform some important questions at the crossroads of the natural and social sciences in the 21st century.

REFERENCES

[1] E. Pennisi, "How Did Cooperative Behavior Evolve?," Science, vol. 309, no. 5731, p. 93, 2005.
[2] R. C. Poudel and J. G. McGowan, "The Dynamics of Human Society Evolution," Newsletter, July 2019, Forum on Physics and Society, APS.
[3] A. J. Leggett, "Reflections on the past, present and future of condensed matter physics," Science Bulletin, vol. 63, p. 1019–1022, 2018.
[4] H. T. Odum and E. C. Odum, Energy Basis for Man and Nature, McGraw-Hill Book Company, 1976.
[5] C. P. Snow, The Two Cultures and the Scientific Revolution, New York: Cambridge University Press, 1961.

# The Architecture of Hope - " Cancer Care Center"

**Upama Khadka**
Himalaya Engineering College, Kathmandu, Nepal

## ABSTRACT

There are people in life that guide you and instill in you the beliefs that carry you through life. There is nothing more rewarding than passing on the knowledge and inspiring others to be great people. This project is dedicated to my sister who was diagnosed with cancer at a very young age of 16 and is a cancer survivor. Her life journey is the main influencing factor for me to do this project. When someone has cancer, their whole family and everyone who loves them goes through that too. Being a family member of a cancer patient and having the closest person to you diagnosed with cancer, I have seen cancer and suffering very closely. Since childhood I always wanted to do something for a cancer patient. Therefore, I decided to do this project Architecture of Hope -'Cancer Care Center'.

We only talk about the medical treatment of cancer, but I have seen that people go through lots of negative psychological issues during and after cancer treatment. The impact of cancer does not end after treatment and that current approaches fail to address the full range of physical, psychological, social, spiritual needs that cancer survivors may have before, during, and after the treatment. This project is specifically targeted to people with cancer, and the main motive is to create a space where all the cancer patients LIVE, SUPPORT and GROW together.

The focus area of this project is to explore and analyze the effect of spaces in the healing process so as to maximize the body's healing potential. The therapeutic spaces, if properly designed, can have the ability to ignite the senses of the human mind towards a regenerative self-healing process. The study here reveals how multisensory architectural experiences, space for social support,and nature, if used correctly, can provide psychological relief to the patient. This project also explores the different examples around the world that created a healing environment for patients and explored Architectural tools in therapy. The design is based on three key elements that stem from a SITE analysis: Wind Direction, Forest Area (Trees) and Site Contour. The theory I used when designing this project is an idea that I call "Contextual" design and is derived from the relationship between the building and the site.

Currently the majority of the human population residing in cities live in densely populated, congested environments and to top it all follow busy lifestyles and work schedules. All these factors have led to an increase in the number of cancer patients. Therefore, it is important to provide quality counselling facilities for both the patient and their relatives. Hence, my hope and architectural knowledge are both instilled in my project and I believe that it would create a social platform for the patients where all the patients support each other emotionally, physically and socially and share some happiness and re-emerge into a better world.

# Design and construction of housing for flood-prone rural areas of Terai

**Shraddha Adhikari**
Architect, Kathmandu, Nepal

## ABSTRACT

Flood is a common water induced disaster following the monsoon rain for several months and river bank overflow in Nepal. The swarming rains during monsoon batters Nepal each year, causing widespread flooding and damage to critical infrastructure and housing. The Terai of Nepal is a low land region and is considered as one of the most severe flood hazard zones in the world. The problem of flooding and inundation in the Terai are more critical due to the change in climate and change in the rainfall pattern. In general, there are various causes of flooding such as soil erosion, flat topography, debris flow and sedimentation and river channel migration. Also, there are other anthropogenic causes like blockage of drainage systems, deforestation, poor planning of settlement and poor design and construction practices of roads. Especially, the low income group people are affected by the flood as the flood wash away land, houses and their vital assets.

Vernacular housing constructions are unique and local technologies of constructions in local areas engrossed by the local people. Terai is rich with vernacular housing technologies too. But these technologies aren't enough for housing to withstand the water induced disaster of monsoon season. This paper highlights the impact of flood disaster on the housing of people in the Terai region of Nepal. The wealthier people use durable materials such as CGI sheets, cement pillars and brick walls. But those who are less well-off have to manage with locally available materials such as bamboo, thatch and earth mud. Once the monsoon season is over, the families intend to build a new house again but with the same old technologies which will once again be swept out by the unforgiving monsoon. The main objective of this research is to distinguish what part of the house is affected by the flood in what probable ways and to give the best possible solution to each problem to build a post – flood house and also converse about design aspects and alternative measures.

The roof, walls, plinth and foundation all are built up of local materials like thatch, bamboo, reeds, earth mud and stone. CI sheets are also used these days. These materials aren't resistant to flood and are vulnerable to secondary hazards of flood like heavy rainfall and strong winds. Waterproofing and wind proofing of all the building materials is necessary along with other structural solutions such as use of hip style roof form with 30 – 40 roof pitch, cross bracing of walls, building houses on piles and cement stabilization of the plinth and foundation although it is relatively expensive but durable. Wider approaches of flood resilience include proper land selection, landscaping, sacrificial ground floors, building on stilts and floating houses, also known as amphibious architecture.

Flood resilient construction should be an important component of the integrated approach to flood risk management. The concept of making space for water and living with floods should be normalized by adapting all safety measures. The solutions and measures presented are cost effective, justifying the economy without compromising the quality. The local masons and contractors should be educated well about such local measures because any improvement in the skills of local masons and small contractors in flood-resistant construction can significantly help to improve the quality standards of non-engineered buildings.

# Design of Affordable and Practical Wheelchair Booster Module

**Smirti Pokhrel, Armoghan Shaheen, Brandon Wrona**
University of Calgary, AB Canada

## ABSTRACT

As of 2019, the W.H.O. estimates that 75 million people use a wheelchair on a regular basis. A large portion of this population operates manually pushed wheelchairs, which leads to fatigue and repetitive stress injuries [1]. Many users face conditions that hinder their ability to push for longer distances or up ramps and rough terrain. Without additional support, these challenges can force wheelchair users to lose independence.

A common alternative for those requiring additional support when using a wheelchair is an electrical wheelchair. Electric wheelchairs provide an advantage on ramps, rough terrain, and long distance but can be bulky and lack mobility in confined spaces. Users have reported difficulties maneuvering backwards or through small doorways, and standard electric chairs are strictly electrically driven, reducing the flexibility of choice for the user. They also tend to be expensive, costing $1500 CAD on the lower end and averaging $3000 CAD [2].

Recognizing the pros and cons associated with both manual and electric wheelchairs, the team decided to create a power add-on that would provide electrical drive while easily allowing the user to disengage and operate the chair manually. The benefit of a removable module includes easy storage, lower initial cost, and the option to switch between power supported or a full- electric drive mode. The power supported drive mode provides power assistance on ramps, inclines, carpets, and other obstacles without obstructing the user's independence.

The kit includes powered wheels mounted on a custom frame, batteries, a control system with a tachometer, and custom mountings designed to fit onto a manual wheelchair. To demonstrate the design, I created 3-D renderings, and draft drawings for these parts as well as a full assembly on a sample modelled wheelchair. The team supported the design by analyzing maximum torque requirements, battery life requirements, maximum and cruising speeds, turning radius on various terrain, and responsiveness of proportional drive controls. The team also created a simplified physical prototype to test the feasibility of the placement on a real wheelchair. I completed full CAD stress simulations which validated that the design would support the expected conditions. For the controls system, a complete Arduino code, circuit simulation, and a miniature circuit prototype were created to demonstrate and validate the implementation of steering, speed control, and motor disengagement. To summarize installation and recommended operation, the group wrote a simplified user guide.

The project was an overall success with the kit meeting our design requirements. The add-on is easily removable, provides a nominal driving speed of 6 km/hr with a maximum speed of 10 km/hr, a 5-hr battery life, and can navigate a 1:12 ramp [3]. The total cost for the kit is around $875 CAD.

****Winner of the Best Student Presentation Award 2021****

References

[1] B. Mason, M. Warner, S. Briley, V. Goosey-Tolfrey, R. Vegter. (2020, May). "Managing shoulder pain in manual wheelchair users: a scoping review of conservative treatment interventions". Sage Clinical Rehabilitation, vol. 34, issue 6, pp. 741-753. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7364791/ [Accessed: 05-Dec-2020].

[2] Costhelper (2020). How Much Does a Wheelchair Cost? [Online], Available: https://health.costhelper.com/wheelchair.html#extres3 [Accessed: 05-Dec-2020].

[3] City of Calgary Advisory Committee on Accessibility (2016). Access Design Standards.