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CENG 440

Final Report

Optimizing Transportation and Land Use for a Sustainable Spokane



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Abstract

Cities handle 70% of the population and are innovation centers of the world, thus reducing urban environmental impacts is integral towards sustainable goals. Civil engineers are tasked with designing and implementing these goals into our existing infrastructure. A group of 18 young civil engineers studying at Gonzaga University recently took a trip to the Netherlands to study their sustainable measures, from transportation to water resources, waste management and buildings and energy. These measures were then analyzed and compared to the US, specifically Spokane. This report addresses innovative changes observed in the Netherlands towards implementing a more sustainable transportation and land use system in Spokane.

The Need for a Sustainable City

Urban development is one of the most important strategies for sustainability because of the expected rise in urban population. By 2050, at least 70% of the world's population will live in cities, compared to 50% now (Nathaniel, 2015). This influx of hundreds of millions of people demands significant infrastructure investment and more efficient resource use and energy consumption. Simultaneously, significant environmental issues such as climate change are becoming our reality and must be addressed now. Therefore, while cities develop to combat the influx of people, it is important to integrate sustainability into these developments. Furthermore, according to Efithia Nathanail's paper "A Novel Approach for Assessing Sustainable City Logistics" sustainability is most practical at the city level because of the inefficiency of state and national governments as well as the diversity and uniqueness of cities. What works for one city might not work as well for another, so it is important for each city to develop a plan. Combining environmental issues with economic and social developments moves cities towards a circular economy.

Circular Economy

Cities are currently operating on the take-make-dispose model, generating a linear economy. Linear economies create a growing demand on cities' infrastructure and waste capacity and have significant negative environmental impacts.

- Greenhouse gas emissions: Urban areas are responsible for up to 80% of global greenhouse gas emissions (Ellen Macarthur Foundation, 2015).
- Air pollution: Up to 80% of urban areas air pollution levels are above the WHO limits (Ellen Macarthur Foundation, 2015).

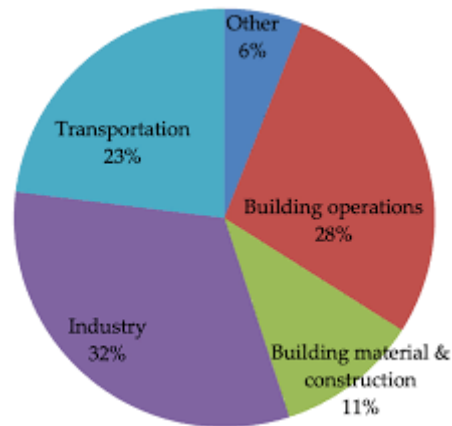
These are the results of a dysfunctional economy that focuses on the demands of today without considering the consequences of the future, thus increasing the need for a circular economy. The Ellen Macarthur Foundation describes how a circular economy "holds the promise of prosperity that is restorative and regenerative by design". This means designing out waste and pollution, regenerating natural systems, and keeping materials in use. These ideas produce an economy that will never run out, and allow it to replenish itself naturally, instead of through exploitation of the

planet and/or lower-class populations. A circular economy must not only innovate greener materials and ideas, but also improve efficiency and dampen need.

Civil Engineers' Role

Civil engineering plays a great role in promoting and implementing sustainable development because many current civil engineering fields contribute high levels of CO₂ emissions.

Figure 1. Global CO₂ emission by sectors 9



Source: Ahmed Ali, K., Ahmad, M. I., and Yusup, Y. (2020). *Issues, impacts, and mitigations of carbon dioxide emissions in the building sector*, Multidisciplinary Digital Publishing Institute, <<https://www.mdpi.com/2071-1050/12/18/7427>> (Jun. 24, 2022).

Figure 1 indicates that civil engineers have a large responsibility to change society.

Transportation engineers need to shift away from the reliance of cars and towards efficient public transportation. These solutions will only be popular with a highly efficient and affordable means of transportation. Meanwhile, structural engineers and construction engineers need to implement greener materials and practices into buildings and construction. Construction will never stop, but a better and more renewable use of our resources can significantly slow down our material consumption. It is the role of civil engineers to put sustainability at the forefront as they are the ones that shape our society and are thus tasked with improving it.

Effect of Transportation

A sustainable city is two-fold. It must meet modern demands and not compromise its environment, people, or economy. Traveling around Europe last semester, it became readily apparent that people are attracted to sustainability, but generally are going to choose the efficient and cheap option. An applicable example is the transportation system. For example, Berlin's exceptional public transportation system provides their citizens with an easy and affordable mode of transportation, highlighted by the U-Bahn, a high-speed metro system that arrives every three to five minutes throughout the city. As a result, in 2019, 600 million passengers used Berlin's U-bahn and 1.6 billion passengers used Berlin's public transportation (City transit, 2022). Improved public transportation keeps cars off the road and can meet the infrastructure demand. Thus, fitting the pre-stated definition of a sustainable city. Providing a sustainable solution that cannot meet modern demands efficiently will be ignored by the people. However, understanding the importance of meeting modern demand by handling billions of passengers while simultaneously taking cars off the road, lowering CO2 emissions and congestion creates a pragmatic sustainable solution. Referencing Figure 1, transportation has a major footprint on the planet, responsible for 23% of global emissions and thus needs to be a vital part of the sustainability movement. Spokane's sustainability action plan (SAP) places a major emphasis on reducing CO2 emissions, air/water pollution and vehicle miles traveled. Berlin's U-Bahn and public transportation system proves how transportation improvement is a prime example on developing a sustainable city, including here in Spokane.

Meanwhile, transportation planning is important for economic development in Spokane. First and foremost, a city's transportation system provides citizens access to jobs. Improved public transportation also provides a cheaper way to travel than buying and maintaining a car. A fair and efficient system allows for every citizen to have adequate access to economic opportunities. The transportation system also moves goods and services which are vital for local businesses. Increased efficiency and less congestion can have a profound impact on the economy, infrastructure investment can boost economic growth by 2.5% (Bos, 2008).

Lastly, the effects on the health and well-being of Spokane are also important. Spokane has a 31.3% obesity rate, creating a high risk of chronic health conditions (Spokane Regional Health District, 2015). Promoting biking and walking increases the physical activities of citizens

and can thus improve their health and lower obesity rates. Furthermore, biking and walking has proven to produce happiness by releasing endorphins, thus stimulating relaxation and lowering stress (Hallisey, 2021).

Effect of Land Use

Meanwhile, land use planning is integral to the environment, economics, and well-being of cities as well. First, land use reflects what matters most to a city. The SAP heavily prioritizes preserving Spokane's natural environment, identifying critical areas like native forests or vulnerable species/ecosystems. Land use planning is responsible for protecting these areas and keeping them away from urban destruction. Furthermore, green spaces, diverse housing developments, accessible transit systems, and walkable neighborhoods reflect a city that cares about sustainability and the quality of life of their citizens, promoting a sense of community in Spokane. According to the Australian Government's Department of Health, community involvement provides a sense of belonging and social connectedness and can have a positive effect on mental health and emotional well-being. Mental health plays a vital role in sustainable development and officially became a part of the UN's Sustainable Development Goals (SDG's) in 2015. In short, healthier citizens are more empathetic and thus more enthusiastic for sustainable development. Thus, sustainability is a two-way street, the people are more conscious of it if the city is willing to change as well. Meanwhile, poor, sprawled out land use reflects a city that is not prioritizing sustainability and may affect the mental health and participation of their population. These results show that land use is important at achieving sustainable goals and improving citizens' morale.

Furthermore, transportation goes hand in hand with land use. Historically, the two have been seen as separate departments, however finding shared goals between the two is important. How much of a city's land dedicated towards roads decides a city's car capacity. Meanwhile, the amount of space dedicated to alternative modes of transportation dictates how prioritized they are. Thus, sustainable development relies on using city's space to prioritize green travel over cars. Therefore, talking about transportation changes goes hand in hand with land use planning.

Transportation and Land Use in Spokane

Spokane's Sustainability Action plan defines environmental justice as "the movement to ensure that no community suffers disproportionate environmental burdens or goes without enjoying fair environmental benefits" (Van Jones). This quote encompasses the core issues addressed by sustainability; an uneven society relies on taking away from somewhere. It is our collective goal to create and ensure equal opportunity, which is reflected in the SAP's transportation and land use goals.

- GOAL 1. Encourage land use policies that support walkable, livable, sustainable communities for all
- GOAL 2. Reduce motor vehicle miles traveled (VMT) and promote active transportation modes
- GOAL 3. Advance alternative and low carbon fuel in regional transportation
- GOAL 4. Integrate Sustainability Action Plan goals, strategies, and actions into City planning

Spokane's GHG target levels shown in figure 2, display how the city is placing a large emphasis on reducing car travel.

Figure 2: GHG target levels

Sector Level GHG Targets: Transportation & Land Use

Vehicle Type	2016 Baseline		2030 Reduction Target 45% & 948,958 MT		2040 Reduction Target 70% & 1,476,155 MT		2050 Reduction Target 95% & 2,003,356 MT	
	Metric Tons CO ₂ e	Percent of Total	Metric Tons CO ₂ e	Percent Reduction	Metric Tons CO ₂ e	Percent Reduction	Metric Tons CO ₂ e	Percent Reduction
Passenger, light duty truck, motorcycle	600,227	28%	300,114	50%	60,227	90%	0	100%
City Fleet (also included above)	10,070	.5%	5,035	50%	2,517	75%	0	100%

Source: Spokane Sustainable Action Plan, 2021

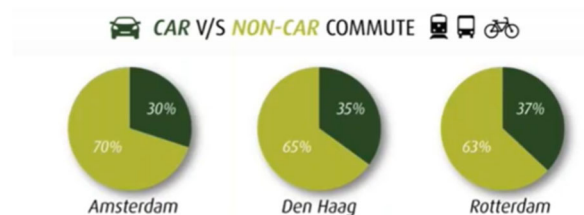
In general, populations are usually going to choose what is most convenient for them. Given the independence and convenience of using cars, they will be popular if the option is there. Around 90% of Spokane residents use motor vehicles as their primary mode of transportation to work. This is reflective of the most convenient way to travel, and ample car

space and parking allows for a high capacity of motor vehicles. Meanwhile, public transportation, while offered, generally is going to be longer and less convenient than driving yourself. This is reflective of how prioritized and accommodating driving is in Spokane's infrastructure. Thus, inflicting change is two-fold, first reducing car capacity and promoting alternative modes.

Transportation and Land Use in the Netherlands

Furthermore, the Dutch have a vastly different perspective on transportation and land use. Plans put in forth decades ago have changed the country's infrastructure away from car centered travel. The catalyst of these changes was the combination of transportation planning with land use planning, allowing the Dutch to develop an integrated mobility system. This system combines modes of travel across various networks (international, interregional, metropolitan, network) allowing travel all over the country without a car. Looking at the graphic below, the system is effective.

Figure 3: Car shares in the Netherlands' major cities



Source: Golub, A. (2019). "Portland State University." *Friday Transportation Seminar: The Success of an Integrated Mobility Strategy: Lessons from the Netherlands for the Pacific West Coast* | Transportation Research and Education Center, <<https://trec.pdx.edu/events/professional-development/friday-transportation-seminar-02152019>> (Jun. 24, 2022).

Thus, proving that major cities can achieve most of their travel through non-car commutes. High speed trains connect different regions and bike paths, trams, and regional trains make those transit centers easily accessible locally. The effectiveness of this system relies on the efficiency of every network, from the first mile to the last. The Dutch commitment to green travel provides a precedent to Spokane and other American cities that the proper integration of transportation planning and land use planning can minimize car travel.

Integrated Mobility System

To bring down transportation CO2 emissions, cars must be taken off the road. However, this can only be done by replacing cars with other reliable and efficient means of transportation. The Dutch have promoted non-car commute by designing transit-oriented cities that involve an integrated mobility system. As defined earlier, integrated mobility systems combine transportation and land use ideas to create a transit-oriented environment. Often the two departments are viewed separately, however combining the two starts by evaluating the shared goals. For example, an efficient and effective infrastructure, a competitive economy, quality spaces, equal opportunity and of course, sustainability. By identifying a common ground, mobility planning and land use can work effectively together to achieve these goals. Next, is identifying a hierarchy of networks.

1. International network: An international network connects cities across the country and continent on a high-speed rail. The Netherlands connects all their major cities through high-speed rails, allowing for efficient long-distance transport without a car. With the United States continued pushed for improved rail system and infrastructure, as highlighted in the new infrastructure bill (The White House, 2021), this system could be coming to the US in the next few decades.

2. Interregional network: Connecting areas in the same region with rails limits daily car commutes, allowing commuters to travel from suburbs into larger metropolitan areas.

3. Metropolitan network: Inside metropolitan areas, metros and trams interconnect neighborhoods and reducing congestion.

4. Local network: Buses, cycling, and walking must be available at the local level for short-distance trips and to connect to the larger networks. The integrated system is only as good as the first and last mile.

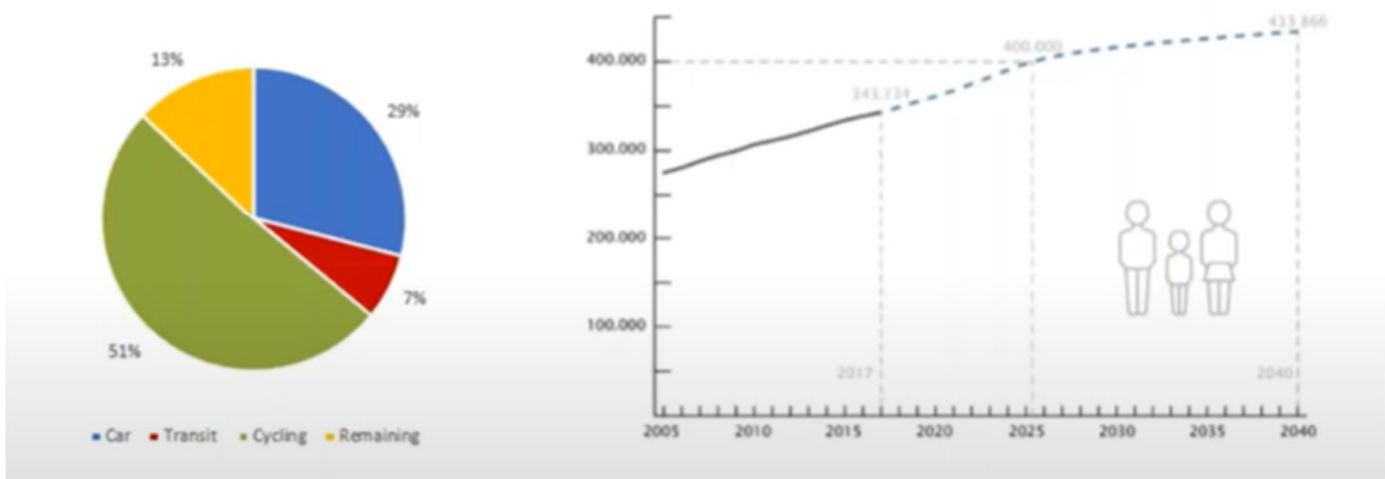
Combining land use and transportation systems is vital in establishing these connections. First, by identifying nodes which are vital for an efficient network. Nodes are key areas with high densities and the most traffic and surrounding areas must be designed for maximum accessibility. The international and interregional networks develop around these important areas to accumulate the most daily trips. After establishing the transit networks as an

efficient car replacement, integrated mobility systems employ many other strategies to promote transit over car trips, which will be listed below.

Utrecht

An applicable case study of an integrated mobility system is the Dutch city of Utrecht.

Figure 4: Modes of transportation and population growth in Utrecht



Source: Golub, A. (2019). "Portland State University." *Friday Transportation Seminar: The Success of an Integrated Mobility Strategy: Lessons from the Netherlands for the Pacific West Coast* | Transportation Research and Education Center, <<https://trec.pdx.edu/events/professional-development/friday-transportation-seminar-02152019>> (Jun. 24, 2022).

Figure 4 highlights Utrecht's notable modes of travel share and expected population growth, expected to reach 430k by 2040. Utrecht currently employs many integrated mobility strategies for their city, as well as for handling the population surge in the future. Spokane has a similar population of 220,000, making Utrecht's strategies an applicable precedent for Spokane.

Utrecht's Existing Plan for now:

A key strategy employed by Utrecht is the utilization of mobility zones, promoting and prohibiting different modes of travel in various parts of the city.

Three Mobility Zones:

1: Downtown: Max priority to bicyclist and pedestrians. Heavily promotes walking and biking by making them the most convenient in one of the most heavily trafficked areas. Furthermore, pedestrian zones limit traffic noise and congestion as well as increase

pedestrian flow by up to 25%, offering opportunities for shopping and dining which result in economic benefits for adjacent businesses (New York City DOT, 2012).

2: City: Balance between modes. Surrounding zones are car accessible however heavily incorporate cycling and walking. Balancing the modes, limits car capacity thus promoting other modes of transportation.

3: Suburbs: Separation of modes. Outside the city each mode is separated to increase capacity.

Other integrated mobility strategies include the planning around the train station. Utrecht has a massive train station, attracting almost 200,000 passengers per day, making it the busiest station in the country (NL Times, 2020). Meanwhile, the surrounding area severely limits car travel. Bike paths run adjacent to the station and bike parking is available directly underneath the station. There are no roads adjacent to the station and parking garages are outside the station. These methods again make cycling and walking the most convenient to the city's most popular destination.

Public transit should be as convenient and simple as possible. The Netherlands OV-chip card is used on trains, metros, buses, and trams across the country. The centralized system makes traveling across different modes extremely simple and affordable. Having an OV card can thus be as effective, versatile, and reliable as a car, no matter where you are in the country.

Traveling by car is only as convenient as the parking available, therefore another strategy employed by Utrecht is limited parking. In Utrecht, parking spots are thus limited and only available for rent. Meanwhile, the parking lots that are available are usually underground, freeing up more space for other things such as wider roads, bike lanes, or green spaces.

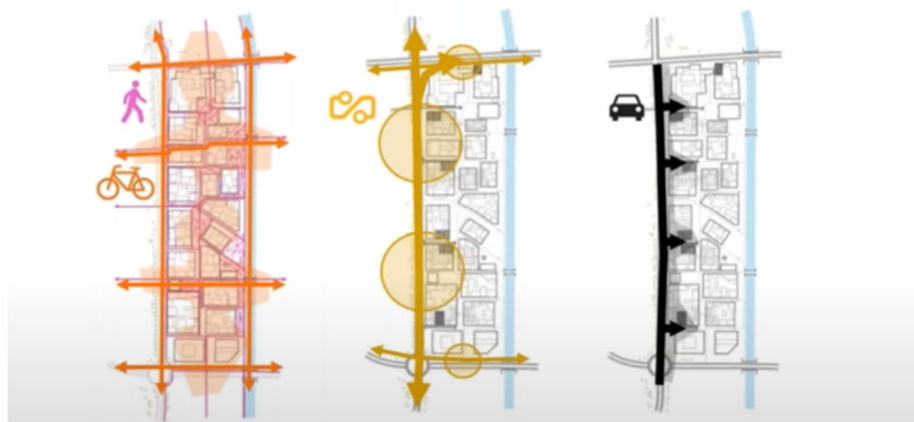
Cars in Europe are parked over 90% of the time, which signifies parking as an unpragmatic use of space (The Ellen MacArthur Foundation, 2021). To combat this, car sharing is popular in the Netherlands and especially Utrecht. From 2019 to 2020, car sharing rose 42% in the Netherlands, with over 700,000 users (Nwanazia, 2021). This maximizes a cars time and space and allows cities to devote less space to parking.

Promoting cycling includes maximizing bike capacity. In Utrecht bike traffic is often separated from cars. This separation decreases conflict points and increases capacity for both cars and bikes. Furthermore, separation also increases safety and comfortability, promoting bike ridership by up to 29% (Alta, 2018).

Utrecht's plan for population increase:

Utrecht is extensively planning for their expected 80,000 population increase. One such idea is the development of a new, highly dense neighborhood. This new development, Merwede, will hold 9,000 units and will be twenty times denser than New York City (Golub, 2019). Merwede is built around very innovative mobility ideas and will set an important precedent for integrated mobility planning. Utrecht has set ambitious goals, like no net car trips gained and only 0.3 cars per household that they hope, that they hope to attain through aggressive strategies. One such strategy is mobility zones as shown in Figure 5 below.

Figure 5: Mobility zones in Utrecht



Source: Golub, A. (2019). "Portland State University." *Friday Transportation Seminar: The Success of an Integrated Mobility Strategy: Lessons from the Netherlands for the Pacific West Coast* | Transportation Research and Education Center, <<https://trec.pdx.edu/events/professional-development/friday-transportation-seminar-02152019>> (Jun. 24, 2022).

The orange zones are accessible by biking or walking, all throughout the city making it the most convenient form of travel. Next, the yellow zones are accessible by transit and lastly the black zones, which are only on the outside of the development, are accessible by car. This intense planning incentives walking and cycling for short trips and transit over cars for medium to long

distance trips. Furthermore, car parking is very limited and is all underground as to conserve space. Having a car available is still always important however, so up to 30% of parking spots will be devoted to shared cars. Thus, families can always have access to cars if necessary without having to pay for one or park. These innovative ideas creatively incentivize ditching the car while still making efficient travel. The inner-city densification project sets an important precedent for future developments to battle rising populations in a sustainable manner.

Plan for Spokane:

Spokane can learn many lessons from the Netherlands in integrated mobility planning and achieve many of the goals set forth in the Sustainability Action Plan.

GOAL 1. Encourage land use policies that support walkable, livable, sustainable communities for all (pg. 42).

Many of the integrated mobility strategies promote walkable, livable, and sustainable communities for all. For example, mobility zones establish pedestrian and cycling only areas that can promote a vibrant downtown. Increasing economic opportunities and benefitting Spokane businesses. Furthermore, limited and underground parking and more centralized roads opens up lots of space in Spokane. These new areas can include green areas, businesses, bike paths, and much more, thus promoting a more livable and sustainable community. Lastly, improved public transportation decreases citizens reliance on owning a car, creating a more equal playing field. Someone should not have to be thousands of dollars and a few hundred a month to buy, insure, and maintain their means of transportation. More affordable and efficient transportation services are possible to the citizens of Spokane. Not needing a car for a daily commute offers more employment opportunities for non-car owners as well. Creating a more equal Spokane will attract businesses and innovative ideas. All these goals are very reasonable because they do not require assistance or reliance on other governments and are solely reliant on Spokane. While money and willpower will always be an obstacle, these strategies have proven to work and will create a more walkable, livable, equal, and sustainable Spokane.

GOAL 2. Reduce motor vehicle miles traveled (VMT) and promote active transportation modes (pg. 43).

Spokane's goal of lowering their CO₂ output is reliant on reducing vehicle miles traveled, which can be achieved through an integrated mobility system. First, by establishing transportation networks (international, interregional, metropolitan, and local). The first two networks, international and interregional are unfortunately out of the hands of Spokane. However, the United States new infrastructure bill, shows promise for future high-speed rail endeavors. These projects will even further innovate Spokane's transit for long-distance travel. In the meantime, Spokane can lobby the state of Washington for rail systems and set up their own metropolitan and local networks. These networks are very important at connecting the outskirts and suburbs of the city towards the center and economic opportunities. Spokane's 90% car usage is due to lack of efficient opportunity of other means of transportation. While establishing the larger networks is a bigger issue, the local networks can still create a very integrated Spokane. Furthermore, other ideas include centralized chip card and car sharing. The convenience of a car is the ability to travel wherever and whenever. These ideas make it simple for citizens to utilize whichever mode of public transportation available to them or utilize a car on days where they might need one. Implementing a centralized chip card and car sharing system is an extremely affordable, effective, and non-controversial way to promote greener travel.

Much of the Netherlands's success can be attributed to their commitment on the national level and the willingness of their citizens. However, the Dutch faced many challenges on getting to where they are now. Their aggressive 1970 infrastructure bill (Bos, 2008) was heavily criticized by the population and car users of the Netherlands and faced many of the same expensive problems Spokane faces today. However, in time they have proven how effective and important infrastructure investment is. Therefore, Spokane can use their example to kick start their own infrastructure changes to create more sustainable and equal transportation.

Conclusion

Spokane has set forth ambitious goals in their sustainability action plan that sets them up for a brighter and greener future. The transportation industry is a central aspect of every city and heavily impacts the economic and social output. As one of the largest CO₂ emitting industries, improved transportation can create a more livable and sustainable city. Spokane's heavily reliance on cars calls for aggressive changes. Such changes can be met with an integrated mobility system, highlighted by the Netherlands continues success in the transportation industry.

These changes will be challenging, but not as challenging as continuing to battle an unsustainable infrastructure that will continue to limit our potential. Adopting sustainable measures is an important action needed right now. Civil engineers and city planners are tasked with implementing these measures and finding ways to create a better world.

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