15. Traffic safety pillars: safe infrastructure

Introduction

This module explores how road design and management can create safer, more inclusive, and more liveable environments. It begins by examining the Safe System approach (particularly the Dutch Sustainable Safety principles), highlighting how they guide modern traffic safety strategies. Key concepts such as speed credibility, self-explaining roads, and psychological aspects of driver behaviour are connected to real-world design choices in both urban and rural settings. Finally, the module covers the role of road asset management, urban design, and the needs of vulnerable road users to understand how infrastructure can be shaped to prevent crashes and support healthier communities.

Learning outcomes

After completing this module, the students should be able to:

Part I:

- explain the Safe System approach and the core principles of the Dutch Sustainable Safety
- discuss the relationship between road design and speed, speed credibility, and speed accelerators and decelerators.
- define the concept of self-explaining roads and its underlying psychological processes.
- apply the learned principles and concepts in real use cases of unsafe urban and rural road environments and propose relevant infrastructural measures (e.g. urban: speed calming measures; rural: paved shoulders, rumble strips) to improve safety.

Part II:

- explain the implications of road asset management (e.g. road maintenance, roadworks) on road safety
- analyse the relationship between urban design and liveability (e.g. shared space)
- design safe and inclusive roads for vulnerable road users (e.g. pedestrians, children near schools, people with disabilities, older people, etc.)

Key messages to learners

Part I:

- The fundamental principles of the Safe System include: (*1*) It is human to make mistakes; the traffic system must be designed to tolerate (unintended) errors made by the road users; (*2*) The traffic system must be designed so that the external forces in accidents do not exceed the human bodies' tolerance for biomechanical impacts; (*3*) The responsibility for road safety must be shared by those who design, build, manage, and use roads and vehicles, as well as the providers of the post-crash care and emergency response; (*4*) All system components must be strengthened to multiply the protection effect; if one component fails, road users should still be protected.

- The Dutch Sustainable Safety was first proposed in 1992. Its core five principles (2nd edition 2005/2006) included: (*1*) functionality, meaning each road should have one function only; (*2*) homogeneity in mass, speed and direction which focuses on separating vulnerable road users from motorized traffic when speeds are not low; (*3*) predictability of traffic behaviour and the road alignment by a recognizable road design; (*4*) physical forgiveness of the road environment, and social forgiveness meaning that road users should anticipate errors by other road users; (*5*) state awareness referring to that road users should be able to correctly assess their task capability which is affected by the driving skills and the fitness to drive. The 3rd edition was published in 2018, basically categorizing the previous core principles to functionality, (bio)mechanics, and psychologics and introducing two new principles of shared responsibility and learning and innovating in the traffic system.
- Safe speeds are determined by the function of the road and the road users that can be encountered on that road. If the main function of the road is mobility of motorized traffic, i.e. throughput, then higher speeds (e.g. 80 km/h, 100 km/h) are desirable and therefore, vulnerable road users should not be allowed on these roads and physical separation is unavoidable in order to comply with the principle of homogeneity. However, if the function of the road is accessibility, then lower speeds (e.g. 15 km/h, 30 km/h) are desirable to guarantee a safe interaction between vulnerable road users and motorized traffic. Finally, if the road is a distributor road, in which mobility function takes place on the road section and accessibility on the road intersections, then intermediate speeds (e.g. 50 km/h) and physical separation from vulnerable road users are advisable.
- One factor that influences driving speed behaviour is speed limit credibility. A credible speed limit is one that meets the expectations raised by the road characteristics and road environment, so that drivers are more inclined to comply with them. There are several accelerators and decelerators factors in the road environment that affect the speed credibility and driving speed of the driver. Examples of accelerators, include open road environment, wide roads, straight stretches, and high quality road surface, while examples of decelerators include narrow roads, closed road environment (e.g. setback of trees or buildings beside the road), speed calming measures, pavement type (e.g. asphalt or cobble stones), raised pedestrian crossings, and curb extensions at intersections.
- On a self-explaining road environment road users know how to behave, simply on the basis of road design. The concept of self-explaining roads is based on two principles of categorization (i.e. functionality of roads) and expectancy (good to explain here the information processing model of Wickens on how expectations are formed). Expectancy increases when there is consistency in how roads of the same function are designed, and clear differences between roads from different functions.
- To address the last learning objective of Part I it is recommended to bring situations from real life and from the surrounding environment of the learners (or alternatively unsafe examples from their surroundings and environment) and ask the learners to analyse them according to the concepts and principles of safe system approach and sustainable safety and propose accordingly measures and changes to improve the safety of these situations.

Part II:

- Designing safe and inclusive roads for vulnerable road users is essential for creating equitable and sustainable transportation systems. The key principles include prioritizing safety, accessibility, and comfort for all, especially those most at risk. Some of the main aspects to account for include: reducing speeds especially in urban areas where vulnerable road users are

frequently present, providing proper and sufficient room for vulnerable road users like pedestrians and cyclists, assuring the needed infrastructural measures for disabled people (e.g. wide, obstacle-free sidewalks, tactile paving, auditory pedestrian signals and extended crossing times at signalized intersections, ramps and lifts at transit stops, level boarding platforms, etc.), increasing drivers' attention nearby school areas and hospitals with proper school zone signage and markers, refuge islands at crossings and extended signal timing to account for slower movement of children and elderly.

- Urban design plays a critical role in shaping liveability, which incorporates the quality of life, social interaction, safety, accessibility, and environmental sustainability in urban spaces. Key aspects to consider is balancing of space and priorities so that all users coexist safely and comfortably, enhancing aesthetics and functionality improving the overall road user experience and encouraging walking, cycling, and public transit, reducing reliance on cars, and promoting healthier, more active lifestyles.
- Shared spaces are one example in which the design enhances liveability by promoting inclusivity and adaptability. A shared space context is characterised by close interactions between different road users at safe and low speeds, relying mostly on negotiations and social interactions rather than clearly defined rules like in traditional road traffic situations (e.g. roundabouts, priority intersections, etc.). An important question to discuss with the learners is under which preconditions can Shared Space be implemented? There is already design guidelines and literature available for shared spaces in which these preconditions are discussed and specified. For example, shared spaces are suitable only in sojourn areas without extraneous traffic (traffic that does not have an origin or destination within the area). For a full understanding of these preconditions the reader is referred to the provided references.
- Road asset management involves planning, maintaining, and improving road infrastructure to ensure it remains safe, reliable, and sustainable over time. This includes proper repair and surface maintenance, skid resistance, road marking and signage visibility and clarity, safety barriers, lighting, vegetation management, traffic flow management during road works and proper road work closure, inspection and repairs of road tunnels and bridges. Therefore, proper road asset management directly influences road safety by reducing risks, improving conditions, and enhancing the experience for all road users. Neglecting maintenance can lead to hazardous conditions, jeopardizing the safety of road users.

Learning activities

Exercise 1

Answer the following two questions considering the road situations shown in the two figures below:

- Which principles of the sustainable safety are applied in each of the road situations, and which are not? Explain your answers.
- Which infrastructural changes and measures would you propose for each of the road environments to adjust the design according to the sustainable safety requirements?

Accra- Kumasi Rd (5.621083, -0.231139)

26 Pumpkin Ave (5.622116, -0.235583).

Exercise 2

Answer the following two questions considering the road situations shown below:

- What are the speed accelerators and speed decelerators in the road environment shown in the figure above?
- What would be in your opinion a credible speed limit for the road above without making any changes?
- Which infrastructural measures would you propose to make the road above self-explaining and improve the safety of the vulnerable road users?

West End Hospital Bypass, Kumasi, Ashanti Region (6.686130, -1.644559)

Exercise 3

Inclusive design which considers the needs of all road users is in many countries mandatory by law:

- Search the urban design guidelines in your country and summarize what does it say regarding taking the needs of people with disabilities into account when designing urban street. What is missing and what can be improved?

Consider the road environment illustrated in the figure below:

- Indicate what changes would you propose to take into consideration the needs of elderly and people with disabilities?

Asafoatse Nettey Rd (coordinates: 5.541543, -0.211989)

Assessment quiz

The assessment quiz can be used as a part of the examination, or as another form of learning activities.

Question 1

State awareness is one of the five principles of the Dutch Sustainable Safety. What does this principle entail?

- State awareness means that the driver is aware of the state of the road. (incorrect)
- State awareness is when the diver is aware of the state of his/her vehicle. (incorrect)
- State awareness is when the driver is aware of his own state and capabilities. (correct)
- State awareness is when the driver is aware of the traffic rules on the road. (incorrect)

Question 2:

What does the term 'speed credibility' refer to?

- The maximum legal speed limit of a road. (incorrect)
- The degree to which the road environment makes a speed limit feel natural to drivers. (correct)
- The difference between posted speed limits and vehicle design speeds. (incorrect)
- The effectiveness of police speed enforcement. (incorrect)

Question 3:

The concept of shared spaces entails that (choose the correct answer):

- All road users can use the space only if they are physically separated to avoid conflicts. (incorrect)

- Shared spaces are roads that pedestrians and cyclists are allowed, but not motorized traffic. (incorrect)
- Shared parking facilities to reduce the number of cars in residential neighbourhoods. (incorrect)
- Roads where traditional traffic controls are replaced by social cues and cooperation. (correct)

Recommended reading and resources for students

- Elvik, R., Høye, A., Vaa, T., & Sørensen, M. (2009). *The handbook of road safety measures. Emerald Group Publishing*. https://doi.org/10.1108/9781848552517
- Methorst, R., Gerlach, J., Boenke, D., & Leven, J. (2007). *Shared Space: safe or dangerous? A contribution to objectification of a popular design philosophy*. WALK21 conference, Toronto, Canada. https://wwbpa.org/wp-content/uploads/2010/12/SharedSpace-Safe-or-Dangerous-Walk21.pdf
- SafetyCube. (2016). *European road safety decision support system*. https://www.roadsafety-dss.eu
- SWOV. (2018). *Sustainable Safety 3rd edition: the advanced vision for 2018–2030*. SWOV Institute for Road Safety Research. https://swov.nl/system/files/publication-downloads/dv3_en_kort_rapport.pdf

Recommended (additional) reading for teacher

- Aarts, L., & van Schagen, I. (2006). Driving speed and the risk of road crashes: a review. *Accident Analysis & Prevention*, 38, 215–224. https://doi.org/10.1016/j.aap.2005.07.004
- Aarts, L., van Nes, N., Wegman, F., van Schagen, I., & Louwerse, R. (2009). *Safe speeds and credible speed limits (sacredspeed): a new vision for decision making on speed management.* 88th TRB Annual Meeting, Washington DC, USA.
- Green, M., Muir, C., Oxley, J., & Sobhani, A. (2024). Safe System in practice: a study of practitioner awareness, support and implementation. *Journal of Road Safety*, 35(2), 36–48. https://doi.org/10.33492/JRS-D-24-2-2286649
- ITF. (2016). *Zero road deaths and serious injuries: leading a paradigm shift to a Safe System*. International Transport Forum. https://doi.org/10.1787/9789282108055-en
- PIARC. (n/d). *Asset Management Manual*. https://road-asset.piarc.org/en
- PIARC. (n/d). *Road Safety Manual*. https://roadsafety.piarc.org/en
- SWOV. (2006). *Advancing Sustainable Safety: national road safety outlook for 2005-2020*. https://swov.nl/system/files/publication-downloads/advancing_sustainable_safety.pdf
- Wickens, C. D., & Carswell, C. M. (2012). Information processing. In G. Salvendy (Ed.), *Handbook of human factors and ergonomics* (pp. 117–161). Wiley. https://doi.org/https://doi.org/10.1002/9781119636113.ch5
- Wickens, C. D., Hollands, J. G., Banbury, S., & Parasuraman, R. (2013). *Engineering Psychology and Human Performance*. Pearson. https://doi.org/10.4324/9781315665177

Prepared by expert

In case you have specific questions, need a discussion partner, or just want feedback on your lecture materials, you may reach out the author(s) of this module. Please, put 'AfroSAFE curriculum' in the email subject.

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