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InfRO@D
EUROPEAN DIGITAL EDUCATION IN RIM

WP3 – Development of techniques for the implementation of the remote teaching and training process with the use of support tools

IO.7 Development of a methodology for conducting design classes with the use of communication tools

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1 ABOUT THE INFRO@D PROJECT

The COVID-19 pandemic has forced a departure from the current functioning of society in many aspects of the economy, travel, work, and education, not excluding higher education. The necessity of remote education is one of the ways to maintain social distancing and protect our health and life.

A preliminary assessment of the situation at universities in European countries indicates that academic staff were not sufficiently prepared to conduct attractive and practical classes in a remote format.

The necessity to conduct classes remotely involves developing a dedicated didactic and training process project, considering the specific requirements of interdisciplinary engineering knowledge. Transferring this knowledge in remote education, due to its large scope, requires various didactic tools (lectures, fieldwork, design, practicals, laboratories, student assignments, and assessment of the progress and knowledge of students and trainees).

The measurable expected final results are:

- Development of a remote learning methodology for Road Infrastructure Management (RIM) as a model solution to provide a basis for extending the methodology to include further aspects of civil engineering and transport.
- Developing an e-handbook for academic staff supporting the remote learning process.
- Development of model digital teaching and training materials dedicated to technical colleges and training for road management staff on RIM:
  - Road safety audit,
  - Roadside safety management,
  - Safety management of vulnerable road users,
  - Road pavement management.
- Developing an e-learning platform with access to project products.
- Appointment of a panel of experts in road infrastructure management.

The InfRO@D project targets the following groups:

1) Students, researchers, and academic teachers at universities.
2) Road authority staff at national, regional, and local levels.
3) Experts, specialists, and practitioners involved in RIM activities, including staff who conduct training in various RIM courses.
4) All users of road infrastructure, as an indirect target group, for whom the risk of road accidents will ultimately be reduced by increasing the effectiveness and efficiency of RIM activities.

The project is also supported by a group of associates who will cooperate with project partners to consult and evaluate the results. They will implement final products and promote the dissemination and accessibility of the project results.

ABOUT OUTPUT IO.7

- **Objective:** Development of a methodology for conducting design classes with the use of communication tools
- **Work package:** The task falls under WP3 – Development of techniques for the implementation of the remote teaching and training process with the use of support tools.
- Target Groups:
  Research and teaching staff from institutions involved in the project and other European institutions.

2 INTRODUCTION TO DESIGN CLASSES

2.1 Element of the learning system

Design activities are one of the most important and integral parts of the Road Infrastructure Management curriculum. Design classes play an important role in the education of future road infrastructure engineers and managers. It allows students and road authority staff to fill the gap between theoretical knowledge gained in lectures and real-world designing challenges. It is safe to say that there will not be a good engineer without detailed theoretical knowledge and a practical approach to the issue in designing. Here are some additional points to emphasise its significance:

1) Practical Application: Design classes allow students and road authority staff to apply what they have learned in the lectures and practical classes directly. It offers hands-on experience designing road infrastructure, which is invaluable for their professional development.
2) Problem-Solving Skills: Design activities often involve various challenges and possibilities, which require students to assess and select different design scenarios considering multiple factors, problem-solve, and make decisions. These skills are vital in the field of road infrastructure management.
3) Collaborative Learning: Working during design classes encourages collaboration among students and road authority staff. They learn to work as a team, exchange ideas, and communicate effectively—a crucial skill set in the industry.
4) Real-World Challenges: Road infrastructure management involves numerous real-world challenges, from addressing safety concerns to optimising traffic flow, recognising hazards on different road infrastructure elements, and fulfilling requirements for all road user groups, including people with disabilities, etc. Appropriate selection of scenarios and designing in detail allow students and road authority staff to develop practical, safe, and reliable solutions.

The teacher also needs to be much better prepared for the design activities. They can expect to be asked problem questions that go beyond the topic under discussion and lecture knowledge. It should be noted that being together makes such contact much easier and shortens the teacher-student road authority staff distance, making it easier for them to ask questions.

2.2 COVID-19 restrictions

Movement restrictions and limited contact due to the restrictions put in place during COVID-19 made the process of delivering classes in designing much more difficult, mainly by reducing interaction between teachers and students. Consequently, the teachers of these classes had the choice of abandoning such classes altogether or using modern technology to deliver IT remotely. The absence of such classes in Road Infrastructure Management would have significantly reduced the quality of teaching and resulted in the non-fulfilment of an essential element in the teaching process. The present methodology will respond to the preparation of materials in a second way, i.e. using IT tools.

Unfortunately, such an approach will result in a much greater workload for the teacher, who must prepare and carry out these activities.

2.3 Expected result

The developed methodology allows for facilitating effective delivery of design classes in the remote mode both with and without the requirement of social distancing related to the epidemic threat. It includes defining didactic scenarios and enabling students to prepare and receive remote support for independent realisation design classes. The scope of the classes involves the identification of current infrastructure, identification of designing problems, assessment of available traffic data, and assessing possible scenarios for newly constructed or reconstructed road infrastructure considering safety and operational problems.

The discussion on effective teaching methods emphasised the importance of creating clear and practical guides. These guides may include multimedia elements, such as videos and step-by-step tutorials that help students understand designing problems by example. Additionally, teachers should provide instructions on preparing presentations demonstrating the most essential design elements. Modern technologies, support tools, and cloud collaboration tools can also help students communicate with each other, work in groups effectively, and receive remote assistance in teacher assistance classes. Additionally, students should know how to present the results of designing for the external audience remotely.

2.4 Types of design activities

Design classes can vary based on specific needs, tasks, and types of infrastructure. They may also be restricted for safety reasons if field inventory of existing infrastructure before design starts is needed. Regarding designing problems, various software and tools can be used. Designing can consider a selection of specific road infrastructure elements (for example, road barriers) or typical geometrical designing with appropriate solutions and scenarios (for example, geometrical designing of VRU infrastructure).

Designing classes related to Road Infrastructure Management issues can include the following activities:

- lectures with an introduction to design,
- data collection,
- current state analyses,
- design of road infrastructure,
- evaluation and comparison of solutions
- work presentation

Before starting designing classes, it is crucial to :

- defining objectives
- identifying problems and obstacles encountered in the course of remote design classes,
- selection of support tools, techniques, and applications,
- development of evaluation scenarios,
- selection of tools for the preparation of publications summarising the completed work.

Transferring design lectures to the virtual classroom is straightforward, but preparing teaching materials for other classes is more time-consuming. Design activities related to Road Infrastructure Management can be categorised based on their duration into the following:

- Single-day classes (designing of typical road infrastructure element, for example, road barriers),
- Multi-day classes (designing more complex road infrastructure considering more factors, for example, overall designing of VRU infrastructure)

One-day classes are short, typically lasting no more than 8 hours, and they may take place throughout the academic year on the premises of the university. Multi-day classes can involve travel to another city for inventory road. These activities require planning a longer stay, which also involves additional costs.

3 SOFTWARE, HARDWARE

Using supporting tools and software and hardware will be an essential element to help implement such activities.

3.1 Software

The COVID-19 pandemic has spurred the rapid development of IT tools to facilitate communication and the preparation of remote classes. A description of exemplary software is provided in section IO.16. It's important to note that the evolution of these tools is ongoing, and other software options will likely emerge in the future. Among the fundamental software solutions, we can highlight the following:

- for remote communication, e.g. Zoom, MS Teams,
- for creating multimedia presentations, e.g. ActivePresenter, PowerPoint
- for data and variables calculation, Spreadsheets, e.g. Excel
- for drawing geometrical solutions, CAD software, e.g. AutoCad
- for video processing, e.g. CapCut, VLC, Movavi Video Converter,
- for pictures, maps processing, e.g. GIMP,
- for Geographic Information System analysis, e.g. Qgis,
- Management of the teaching process, e.g. Google Classroom.

Efforts were made to select software with open-source or free licenses for educational use.

3.2 Hardware

When developing the methodology for design classes that require inventory work, our primary consideration was to make it cost-effective for both the academic staff and students. We aimed to utilise relatively affordable equipment for most of the tasks:

- smartphone or sports camera for video recording and photo collection
- measuring devices.

4 METHODOLOGY FOR DESIGN CLASSES

4.1 Assumptions

We prepared to conduct both one-day and two-day design classes with a maximum implementation time of two working days. As part of our methodology preparation, we developed the following scenarios for teaching these classes:

A. Designing of elements of infrastructure - selection of road barriers
B. The complex design of road infrastructure for VRU - geometrical design.

These scenarios incorporate various materials and methods, including:

1) Teaching designing selected infrastructure elements based on guidelines.
2) Instructing on selected infrastructure elements using online digital maps.
3) Teaching conducting inventory work of infrastructure considering safety issues
4) Teaching presentations of various solutions for the same site and comparing them.
5) Teaching using software, mainly spreadsheet formulas and CAD

It's essential to highlight that, in the case of inventory work, the paramount concern is ensuring the safety of all participants. This involves implementing hazard information procedures and conducting a brief training session led by the teacher.

All scenarios will be discussed using the examples of two selected subjects:

- Roadside Safety Management.
- Safety management of vulnerable road users.

4.2 Roadside Safety Management

Road Infrastructure Safety Management (RISM) is a process that involves various activities, such as Roadside Safety Management (RSM). One of the objectives of RISM is to identify and verification of any deficiencies in existing road sections to reduce risk for all groups of users. One of the essential parts of RSM is safety provided by road barriers. Road barrier designing is a complex problem and require applying particular procedure considering many variables.

Work should be carried out in a team of 2 specialists/students to assess one road section based on national standards and guidelines for selecting road safety barriers. This will make it possible to develop future cooperation and monitor and check each other's work.

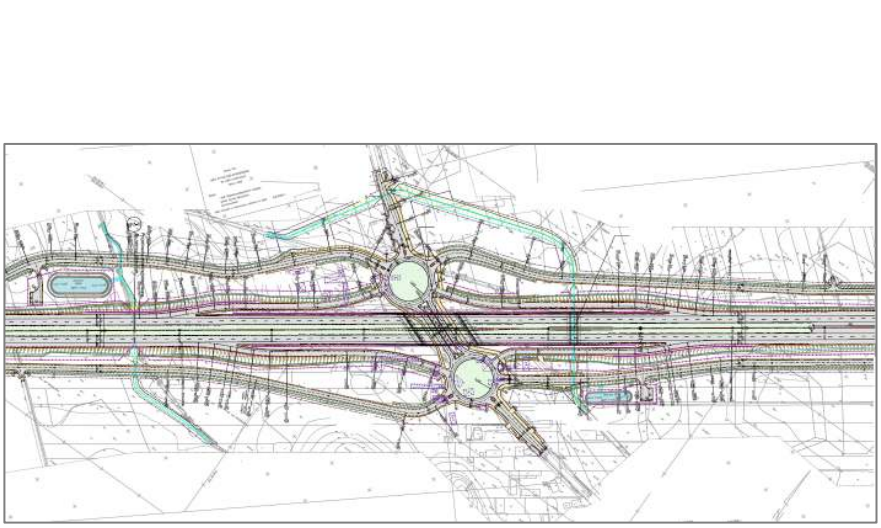
The teacher's preparation for the design classes is an essential element in the teaching process. If the teacher prepares the materials, the following are recommended:

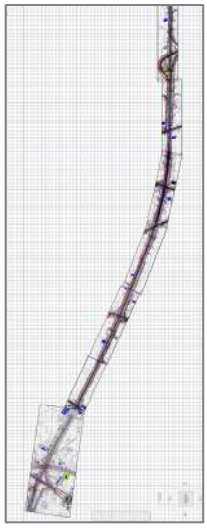
- PDF maps,
- Road geometry and traffic data (preparation of road sections with minimum lengths of 3km, completion of Annual Average Daily Traffic with structure of vehicle data)
- Excel form to calculate the type of barrier,
- National standards and guidelines for the selection of road safety barriers.

Preparatory and design work for road barrier design tasks should include the following issues (PL example):

Stage I – Preparatory work (prepared by teacher)

- Step 1. Characteristics of the analysed object, based on project and traffic data (Figure 1).





Road class	*A*
Divided	*Yes*
Number of lines	*4*
Cross-section of the road	*2x2*
Length of the section	*L = 6 025 m*
Obstacles in roadside	*P1* – Bridge column, *P2 -…*
Distance to obstacle	*P1= 2m, P2= 1,6 m, P3=…*
Speed limits	*140 km/h*
Annual average daily traffic (AADT)	*19 596 veh/day*

Figure 1. Example of road geometry and traffic data

- Step 2. Identification of hazards and sources of risk of accidents caused by a vehicle run-off road (Figure 2).

From [km]	To [km]	Section length	Direction	Location	Source of hazards
135,618	135,648	0,030	North	Median	Bridge column
135,648	135,710	0,062	North	Median	Bridge column
135,710	135,714	0,004	North	Median	Bridge column
135,714	136,136	0,422	North	Median	Opposite direction traffic lanes
136,136	136,312	0,176	North	Median	Opposite direction traffic lanes
136,312	136,612	0,300	North	Median	Opposite direction traffic lanes
136,612	136,650	0,038	North	Median	Bridge column
136,650	136,716	0,066	North	Median	Bridge column
136,716	137,020	0,304	North	Median	Opposite direction traffic lanes
137,018	137,026	0,008	North	Median	Opposite direction traffic lanes
137,026	137,048	0,022	North	Median	Bridge structure > 20 m long
137,048	137,056	0,008	North	Median	Opposite direction traffic lanes
137,056	137,458	0,402	North	Median	Opposite direction traffic lanes and gantry
137,458	137,520	0,062	North	Median	Bridge column
137,520	137,588	0,068	North	Median	Bridge column

Figure2. Example of hazard data

Stage II – Designing (designed and calculated by student)

- Step 3. Determining the intensity of AADTT trucks
- Step 4. Determining the probability of vehicle penetration through the road safety barriers (Table 1).

Table 1 Classification of levels of probability of vehicle penetration (passing) through the road safety barriers for dual carriageways with Vdop≥70km/h

Probability of vehicle penetration through road safety barriers P	Annual Average Daily Truck Traffic $AADT_T$ (veh/day)
Very Low	<5 000
Low	5 000 – 10 000
Medium	10 000 – 15 000
High	15 000 – 20 000
Very High	>20 000

- Step 5. Determining the level of consequences of the risk of accidents caused by vehicle penetration through the road safety barriers (Table 2).

Table 2 Classification of KZ hazard levels caused by a vehicle penetration through road safety barriers on the analysed road section

Level of hazard PZ		Consequences of the risk of accidents KZ		
		Vdop ≤70 km/h	Vdop 70-90 km/h	Vdop ≥100 km/h
PZ1	Low	KZ1	KZ1	KZ1/KZ2
PZ2	Medium	KZ2	KZ2	KZ2/KZ3
PZ3	High	KZ3	KZ3	KZ3

- Step 6. Determination of the risk matrix

Table 3 Risk classes for a vehicle penetration through road safety barriers

Probability of vehicle penetration through road safety barriers P	Consequences of the risk of accidents KZ		
	Minor	Moderate	Catastrophic
Very Low	A	B	C
Low	B	C	D
Medium	B	C	D
High	C	C	E
Very High	C	D	E

The most effective way to conduct lessons is a presentation with a short reminder of the lecture and an explanation of all of the steps, including both stages I and II. The teacher should discuss together with the student an example. Each group of students should prepare a short presentation of work (similar to the teacher's presentation), including all required steps. The results of the design should be discussed with other groups.

- Step 7. Determining the containment level of the road safety barriers

Table 4 Road safety barriers containment levels on divided motorways and expressways

Type and class of road	Annual Average Daily Truck Traffic	Consequences of the risk of accidents KZ		
	$AADT_T$ (veh/day)	Minor	Moderate	Catastrophic
Divided motorways and expressways (Vdop≥100km/h)	<5 000	N2*	H1/L1	H2/L2
	5 000-10 000	H1/L1	H2/L2	H3/L3
	10 000-15 000	H1/L1	H2/L2	H3/L3
	15 000-20 000	H2/L2	H2/L2	H4b/L4b
	>20 000	H2/L2	H3/L3	H4b/L4b

4.3 Safety management of vulnerable road users

Road Infrastructure Safety Management (RISM) is a process that involves various activities, such as the Safety Management of Vulnerable Road Users (SMVRU). One of the primary objectives of RISM is to design infrastructure to reduce the risk for VRU. SMVRU is a collaborative effort. Therefore, additional techniques will be provided to allow group members to work remotely under the guidance of a teacher.

One of the possible actions under RISM to improve the road safety of VRUs is to design their infrastructure to the highest standards. SMVRU is an effort to improve road safety for pedestrians, cyclists, and motorcyclists, who are more susceptible to accidents on the road.

To facilitate SMVRU and RISM, additional techniques are provided to enable group members to work remotely, allowing them to collaborate effectively under the guidance of a teacher or facilitator. This approach enhances the efficiency and effectiveness of the safety management process, ensuring that road infrastructure is as safe as possible for all users.

It's important to note that this procedure is designed explicitly for mixed-traffic areas where VRU safety problems are significant.

Work should be carried out in a team of 2 specialists/students (1 group) to design VRU infrastructure in mixed traffic areas based on national standards (guidelines) for VRU infrastructure (sidewalks, bike paths, pedestrian crossings, bus bay) for the selected urban area. This will make it possible to develop future cooperation and monitor and check each other's work. Also, it is essential to compare and discuss between designers to select the best solution. Therefore, the design problem should be parallel solved by two groups of students.
The teacher's preparation for the design classes is an important element in the teaching process. If the teacher prepares the materials, the following resources and activities are recommended:

- Digital or prepared PDF maps as a background to design VRU infrastructure (Figure 2).

- Google Earth, geoportal.gov.pl, etc. (websites with satellite images) – for remote inventory work (Figure 3), also field inventory can be conducted.
- CAD software – for example, AutoCAD to support design work (Figure 4), tutorials for using CAD software may be suggested, as well as teachers should remotely present CAD software applications and use them.
- Standards and guidelines for VRU infrastructure design (based on lecture or shared resources).
- Data about traffic volume, traffic organisation, public transport lines and stop locations, speed, etc. (prepared by teacher – Figure 2).
- Land use for assessment of origin and destination of VRU trips and infrastructure location (based on map Figure 2).
- Examples of project results (Figure 5).

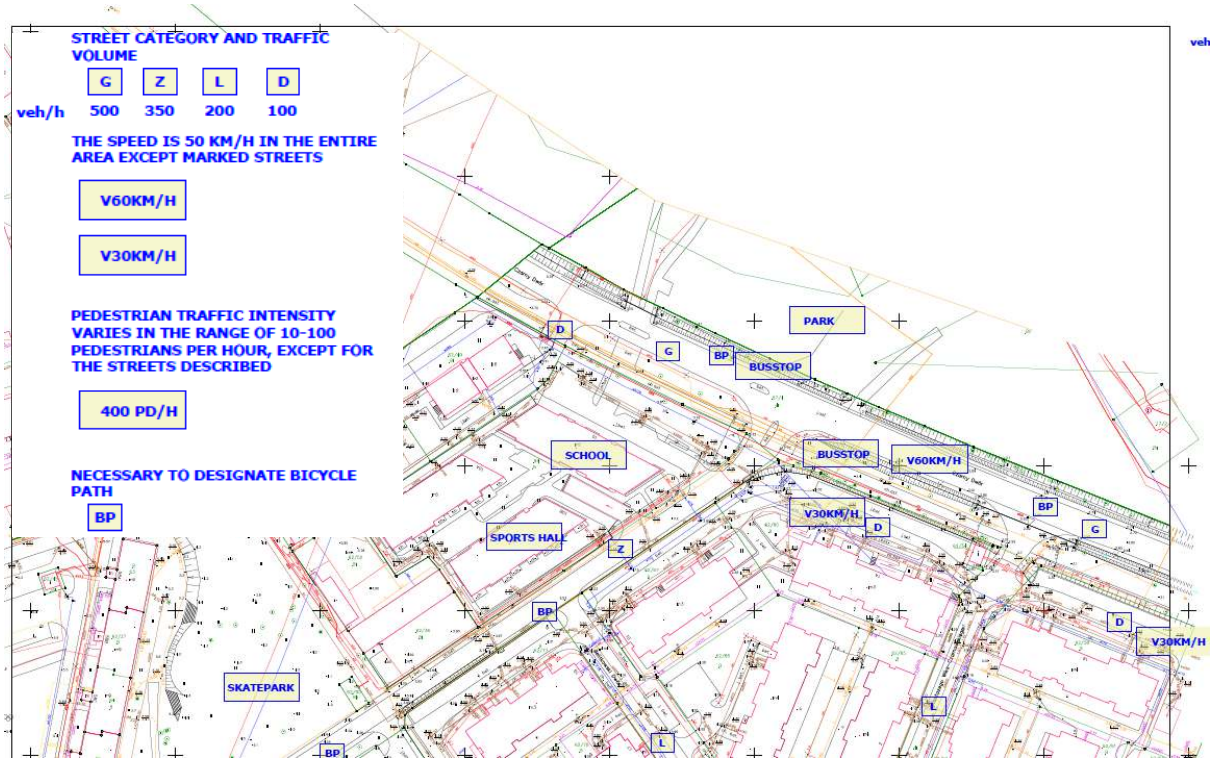


Figure 2 Example of map prepared by a teacher with traffic data

Figure 3 Example of remote inventory work (https://maps.app.goo.gl/FmPQPyrQf2qhpUsQA)

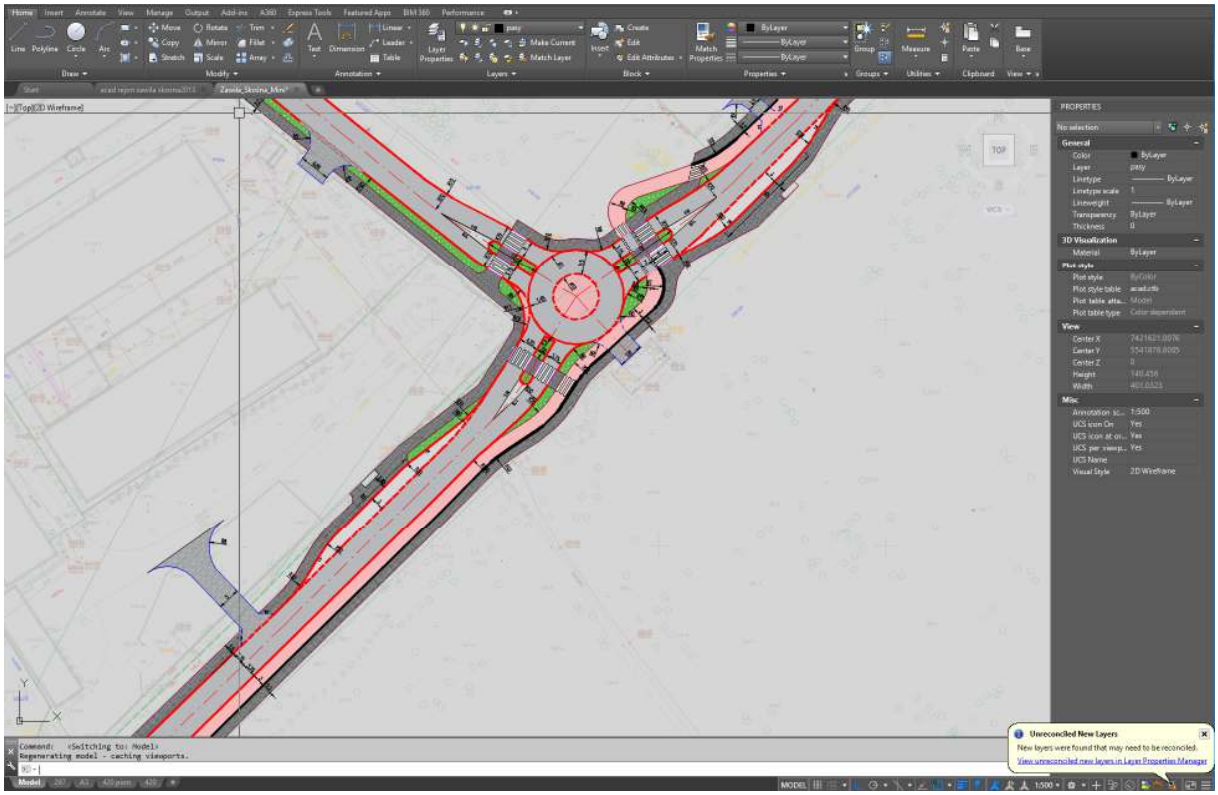


Figure 4 Example of AutoCAD software application

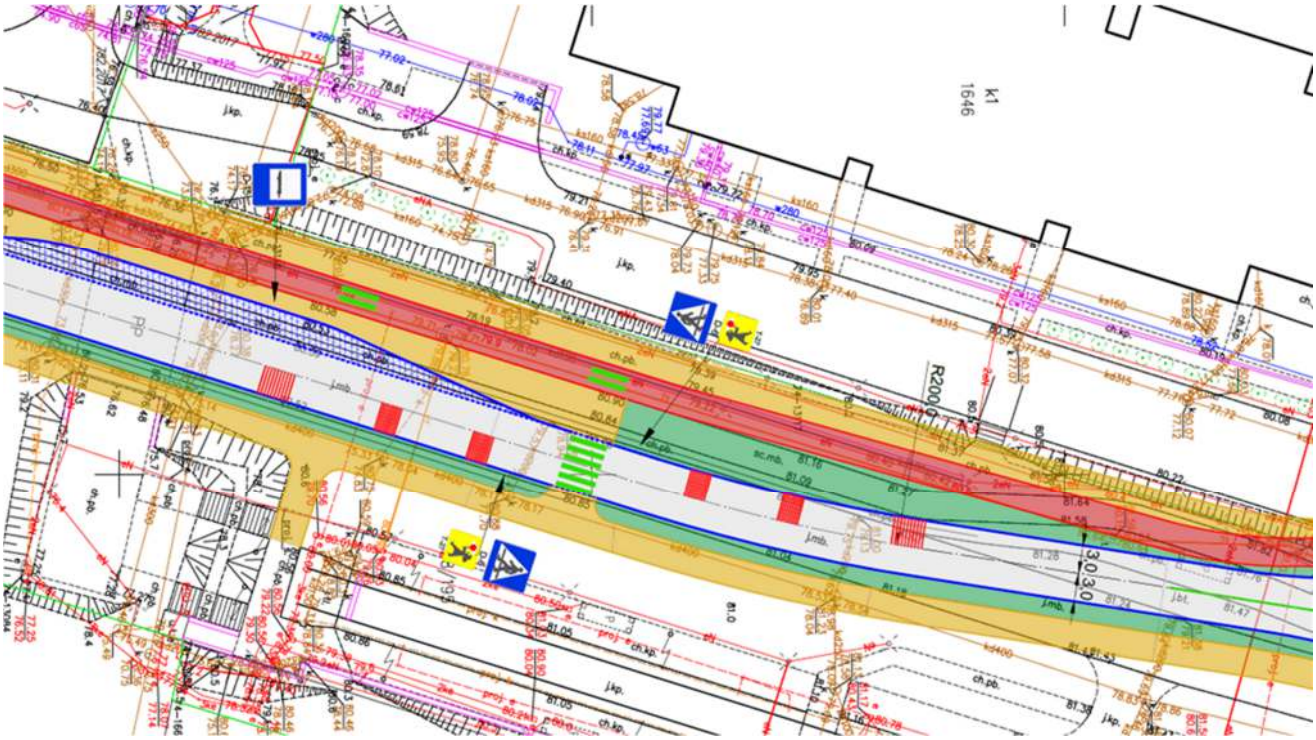


Figure 5 Example of design class result

Expected task results from design classes:

- Identification of the origin and destinations for VRU traffic based on the prepared map (schools, residential buildings, etc.).
- Conducting an inventory work of the area based on satellite images or field inventory.
- Identification of the existing traffic organisation.
- Considering vehicle and VRU traffic volumes.
- Designing solutions for VRU.
- Comparing proposed solutions in groups – discussion.

An essential part of design class is a method of interaction between teacher and student to provide personalised support, which is mandatory. Therefore, design classes should include possibilities for remote sharing, including the use of virtual machines and remote desktop sharing (to use the same drawing commonly). Students will work on drawings in shared spaces. Teachers should be able to evaluate student work with the option of adding comments and changes remotely (to shared drawing).

4.4 Road pavement management

The design part in the field of road surface management consists primarily of predicting pavement condition changes over time and maintenance and treatment plans for the road sections. Assessment is key to gaining insight into the condition of road infrastructure.

The design part of the work can be divided into the following key stages:

1) Prediction of the development of pavement damages and changes in its condition during exploitation.

2) Planning maintenance and repair/treatment works aimed at improving the condition of the pavement.

By following these steps, road authorities and maintenance teams can make informed decisions regarding necessary repairs, maintenance priorities, and overall infrastructure management.

The practical part in the field of road surface management is planned as the student's own work. The teacher's task is:

- assigning work to be completed by students,
- checking the work done by students and making any corrections,
- preparation of didactic materials (videos, standards, guidelines, etc.).

4.4.1 Teacher preparation

The teacher's preparation for the design classes is an essential element in the teaching process. The teacher prepares the materials, the following are recommended:

- pavement management guidelines/standards
- models of prediction of pavement condition changes
- maintenance, repair and treatment methods.

4.4.2 Prediction models for pavement condition changes

In the case of this part of design classes, the teacher should:

- provide students with general assumptions for prediction models of pavement condition changes (Figure 6),
- assign tasks to be carried out (Figure 7),
- determine how to implement the tasks (Figure 8),
- check the degree and correctness of tasks completed by students.

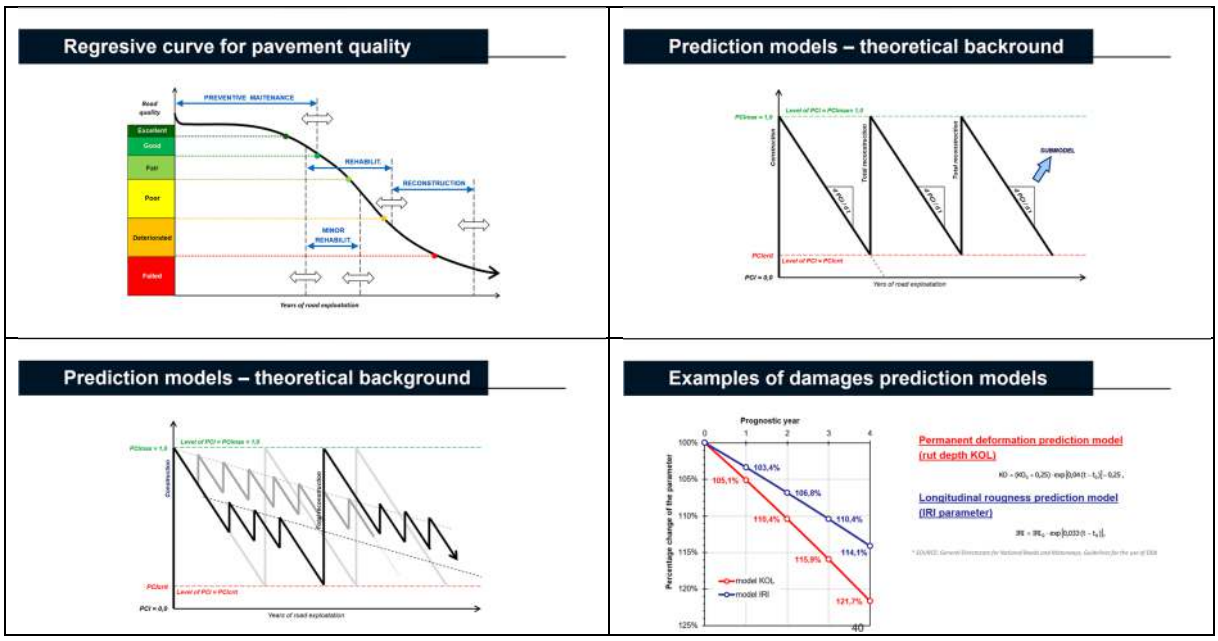


Figure 6 Example of information about pavement condition changes models.

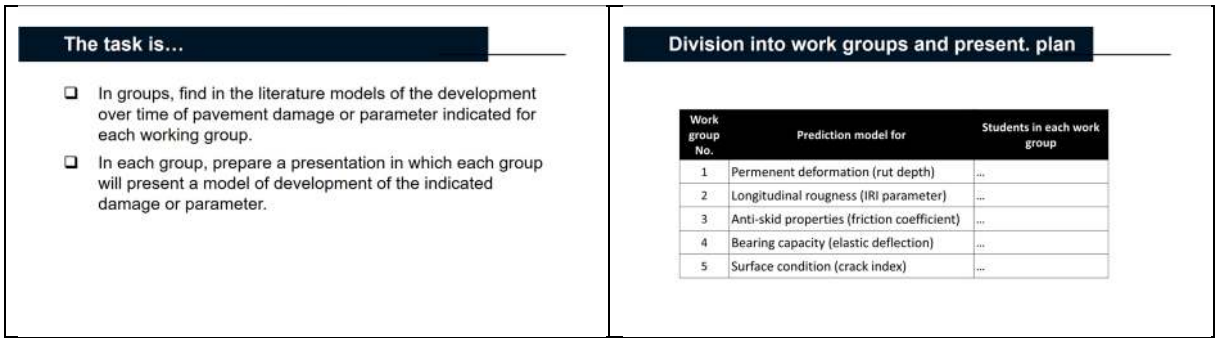


Figure 7 Example of the task for the student (predictive models)

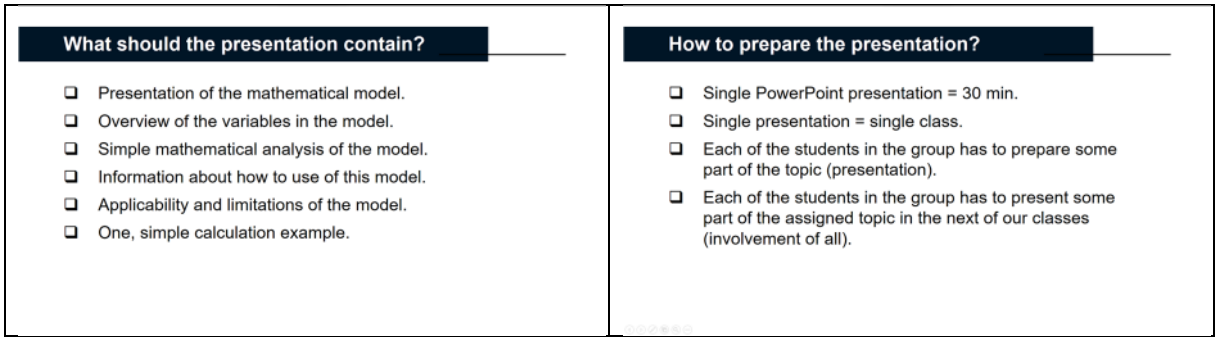


Figure 8 Example of the method of students' task implementation (predictive models)

4.4.3 Maintenance and treatment plan for the road sections

In the case of this part of practical classes, the teacher should:

- provide students with general assumptions for a maintenance plan and treatment methods (Figure 9, Figure 10),
- assign tasks to be carried out (Figure 11),
- determine how to implement the tasks (Figure 11),
- check the degree and correctness of tasks completed by students.

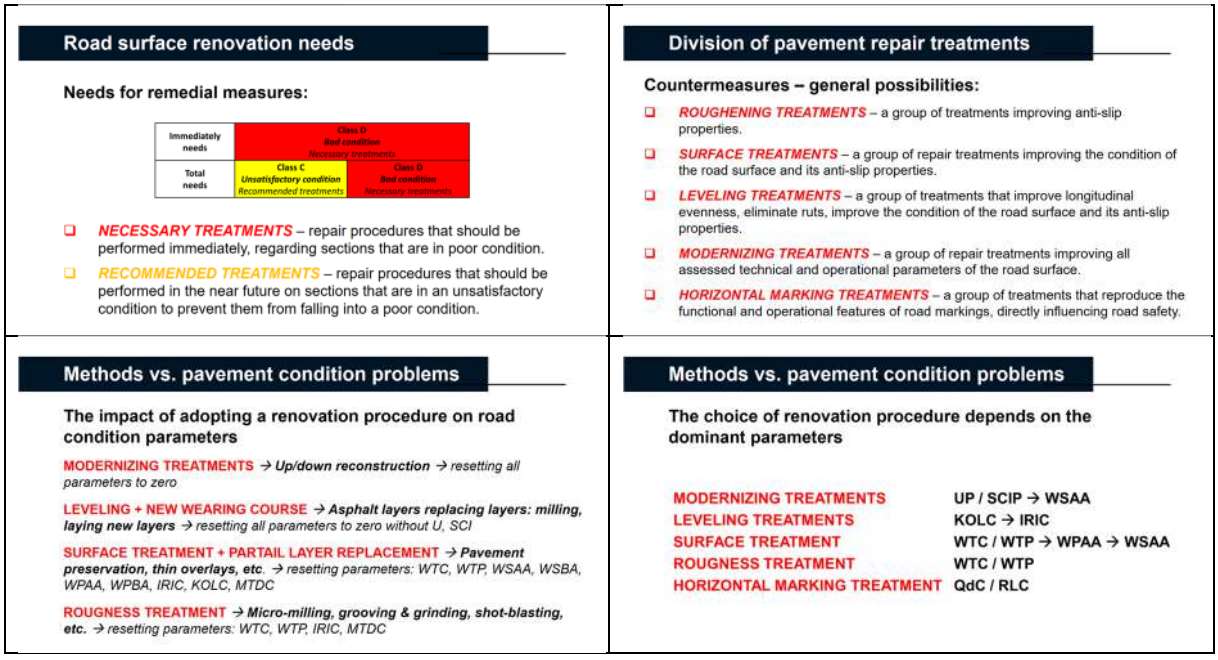


Figure 9 Example of information about maintenance plan and treatment methods (presentation)

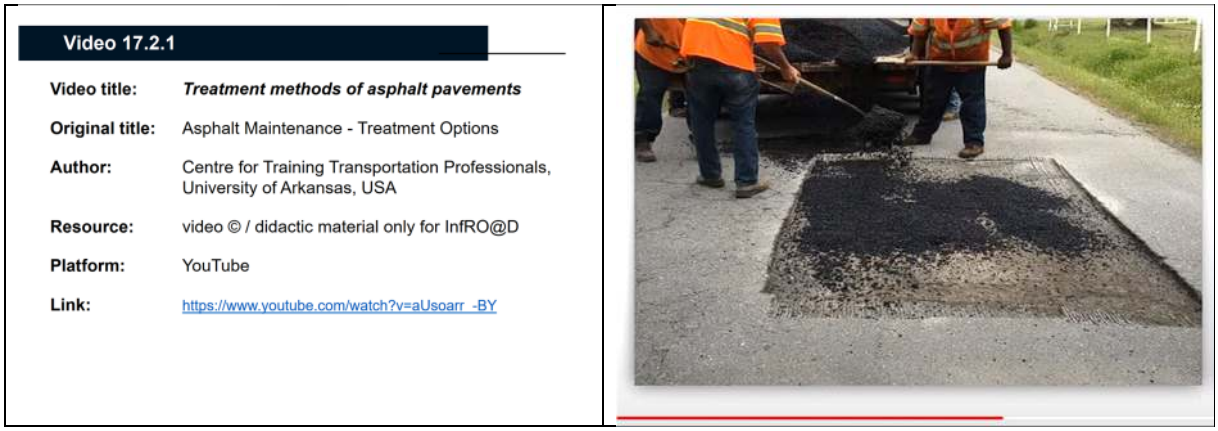


Figure 10 Example of information about maintenance plan and treatment methods (video materials)

The task is…

In groups, based on previous work, propose maintenance treatments for immediate implementation, recommended treatments, provide a group of treatments, their type and a plan for their implementation (schedule). Show your proposition with the use of short PowerPoint presentation.

What should the presentation contain?

- Short presentation of the road section.
- Short look at current pavement condition.
- Results of assessment of pavement condition.
- Maintenance plan in table:
  - *propose maintenance treatments for immediate implementation,*
  - *recommended treatments,*
  - *provide a group of treatments, their type*
  - *plan for treatment implementation (schedule)*

How to prepare the presentation?

- Single PowerPoint presentation = 30 min.
- Each of the students in the group has to prepare some part of the topic (presentation).
- Each of the students in the group has to present some part of the assigned topic in the next of our classes (involvement of all).

Division into work groups and present. plan

Work group No.	Road section	Students in each work group
1	Road section No. 1	…
2	Road section No. 2	…
3	Road section No. 3	…
4	Road section No. 4	…
1-4	Joint discussion	All students

Figure 11 Example of the task for the student and method of students' task implementation (maintenance and treatment plan)

5 SUMMARY

The methodology outlined here offers insights into preparing design classes on Road Infrastructure Management. This methodology covers class types and essential tools and software for enhancing the quality of teaching materials significantly.

The methodology includes scenarios for conducting classes using materials prepared by teachers, civil and transportation engineering students, and road authority staff at national, local, and regional levels.