Implementing the GOW30 road category in Enschede

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ENSCHEDE

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1 PREFACE

This document is the bachelor thesis “Implementing the GOW30 road category in Enschede”. It has been written to fulfil the graduation requirement for the Civil Engineering programme of the University of Twente. This thesis was worked on from the 15th of April 2024 until the 20th of June 2024.

While my interest in the traffic domain of civil engineering has not always been present, during my bachelor's, I realised that I was most interested in traffic. More specifically, local solutions to traffic problems piqued my interest. This is why I attempted to arrange a bachelor thesis assignment at the municipality of Enschede. I thought it would be interesting to do my assignment on a traffic network I use and know well. Thankfully, this succeeded and in consultation with the municipality, we decided on an assignment on the new road category GOW30. I was to make a broadly applicable solution to a road design challenge for this. I gladly accepted this assignment because it is a very relevant topic, and I am grateful for the freedom to adjust the assignment to match my learning goals and interests.

I want to thank my supervisor from the University of Twente, Oskar Eikenbroek, for providing useful feedback and insights and giving me the freedom to make the assignment my own. Next, I want to thank my supervisor from within the municipality, Rens Haverslag, for introducing me to the organisation, connecting me to the right people and providing me with useful insights for the assignment.

Guus Verweij

20 June 2024

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3 READING GUIDE

In this thesis, some concepts and abbreviations are used, these are explained in this chapter.

When discussing the road network, only roads within build-up areas (binnen de bebouwde kom) are part of this research.

Road category: In the Netherlands, roads are given a category based on their function. CROW specifies the design characteristics of these categories.

ETW: ErfToegangsWegen, is a road category for roads that directly access residential areas. The residential function is central and car traffic should adapt. These are 30 km/h roads and 15 km/h yards (erven) within built-up areas (SWOV, 2023a).

GOW: GebiedsOntsluitingsWegen, is a road category for roads that connect ETW to motorways and highways. There are three types of GOW roads. These are the 50- and 70 km/h roads, which everyone has used. The 30 km/h road category, GOW30, has recently been added (SWOV, 2023a). This road category is the focus of this thesis.

Ministry of IenW: Ministerie van Infrastructuur en Waterstaat, Ministry of infrastructure and water management of The Netherlands.

BABW: Besluit Administratieve Bepalingen inzage het Wegverkeer, Dutch implementation rules regarding roads.

CROW: The Dutch national knowledge platform for infrastructure, traffic, transport, and public space.

Speed limit credibility: "A limit that drivers consider logical or appropriate in light of the characteristics of the road and its immediate surroundings through specific consistency and continuity of road design, including the type of the road, road layout, road surface, road curvature, traffic density, weather conditions and a mix of traffic." (Yao et al., 2019)

TOR: Toetsingskader inrichting Openbare Ruimte or review framework for design of public space. This document provides standard agreements on how to design public space. When the TOR is referenced in this report, the TOR of Enschede is meant (Gemeente Enschede, 2024).

4 SUMMARY

The goal of this thesis is to develop a design framework for the implementation of a new road category, GOW30, in Enschede. This is done by specifying the existing CROW framework (2023) to make it applicable to Enschede. The framework aims to offer road designers a basis on which to design a road.

Three main research questions are answered in this thesis:

1. Which roads in Enschede are categorized as GOW30 when applying the consideration framework of CROW (2021)?
2. Which road design characteristics should be included or excluded in the framework for GOW30 roads in the municipality of Enschede?
3. How do stakeholders foresee the proposed implementation of GOW30 in Enschede?

This is done by following the following steps:

1. Use the CROW framework to reassess the existing road categorisation of the municipality.
2. Determine the characteristics of the GOW30 roads in the municipality.
3. Discuss the implementation of GOW30 roads with the stakeholders.
4. Create a design framework for GOW30 roads in the municipality.
5. Validate the design framework.

Following these steps has resulted in a new road categorisation map and corresponding characteristics based on the consideration framework of CROW. Requirements and wishes from stakeholders for GOW30 roads have been gathered. These have been combined into a design framework which gives multiple combinations of design characteristics of the roads based on the characteristics of a GOW30 road.

This framework has then been validated by applying it to a road in Enschede, by validating it with the stakeholders and by validating it with CROW to see if the framework is in line with the vision of CROW.

This validation has shown support for the design framework for GOW30 although some additions have been advocated for by the stakeholders. These additions have since been implemented in a final revised version of the design framework for GOW30 in Enschede.

This research provides a guide for municipalities, particularly Enschede, to implement GOW30 roads effectively, by ensuring support from stakeholders.

5 INTRODUCTION

As traffic safety gains increasing political importance in the Netherlands, research indicates that significant measures are necessary to achieve the ambition of halving the number of road casualties by 2030 compared to 2020 (Craen et al., 2022). This will inevitably result in changes in the road design of the Netherlands in the coming years. Municipal 50 km/h roads, the so-called GOW50 road category, are over-represented in the traffic casualty statistics by being responsible for 27% of them in 2022 (SWOV, 2023b).

These GOW50 roads have therefore been the focal point of action on traffic safety in recent years and policy changes regarding these roads have already been made. The first step of this was in the Dutch parliament with the passing of a motion about creating a consideration framework. The leading principle of the framework should be that the road network should have a maximum speed of 30 km/h (Kröger & Stoffer, 2020). The idea of this motion is that a decrease in speed will lead to improved road safety. With lower speeds, road users have more time to anticipate, and impact will also be reduced because of the lower speed difference between road users. While the idea of 30 km/h as a leading principle is no longer pursued, the toolkit for road managers has been expanded to enable them to create a safer road network.

This has been done by introducing a new road category, GOW30 (Dijkstra & Petegem, 2019), and designing roads to have a credible speed limit to ensure the desired travelling speed is adhered to (Andriesse, 2021). The consideration framework proposed in the motion should provide road network managers with a schematic overview of how to decide which road category a road should have. The road category determines the basic design characteristics of the road. After a lengthy process, municipalities are now looking for ways to implement this new road category in their road network. The implementation has proved difficult because there are no specific guidelines for how to do it and since GOW30 is a new road category, there is no experience to be learnt from. Next to that, the implementation should also be supported by the whole municipality, not just the traffic engineers. The implementation of changes in the road network is carried out and prepared by many parties. If there is no support for the implementation by these parties, it will not be conducted.

This thesis research presents the results of how GOW30 can be implemented in the municipality of Enschede. The process is described, and the resulting design framework is presented. This is done using the following structure, first in Chapter 6 the context surrounding the problem of GOW30 roads is further elaborated on. Chapter 7 formulates the research objective, scope, and questions. Then, the results of the study are presented in Chapter 8. This starts with an overview of the methodology used, and then the results of the steps are given. These results are then discussed in Chapter 9. With the conclusion following in Chapter 10. Finally, Chapter 11 gives further recommendations based on this research.

6 RESEARCH CONTEXT

The consideration framework previously mentioned in the introduction was realised and proposed by CROW (2021) and can be found in Appendix A. This consideration framework aims to aid road network managers in choosing which road category a road should have. This can be done for new roads, but also for analysing the existing GOW50 road network and deciding if and which roads should have a different categorisation. The CROW report supporting the consideration framework clearly states that the framework should only be used on new roads or existing GOW50 roads (CROW, 2021). It is not meant to upgrade current ETW30 roads to GOW30 or GOW50.

Alongside this consideration framework, CROW has published a provisional version of design characteristics for GOW30 roads (CROW, 2023). These design characteristics help in ensuring a credible speed limit. This credibility is determined by the design of the road and its surroundings (Andriesse, 2021). Alongside this, the different road categories must be distinctive from each other to help the road user recognise the different categories (CROW, 2023).

The goal of the characteristics is to provide road managers with an overview of how these GOW30 roads should look and what the differences are compared to GOW50 and ETW30 roads. The design characteristics for GOW30, as provided by CROW, are provisional. This is because the effect the design characteristics have on the credibility of the speed limit has not yet been shown in practice.

The road characteristics in this provisional version are mostly text-based and open to interpretation. It does not give a clear overview of what GOW30 roads should look like. Using the provisional version of the design characteristics still leads to a wide range of possible designs for GOW30 roads. This makes it difficult for road network managers to implement the road category in their network. The wide range of possible designs also makes consistency in the road design difficult, which is necessary for a credible speed limit (Yao et al., 2019).

This credibility of the speed limit determines if road users are inclined to adhere to the speed limit. The characteristics that help in the credibility of the speed limit have recently been reevaluated by SWOV (Kint et al., 2022). For some characteristics, they found that the impact on the credibility of the speed limit was not well supported. As a result, further research on how to determine the effects of road characteristics was proposed, which has not yet yielded results. However, they did find characteristics where the effects on the speed limit credibility were well supported. These design characteristics have already been implemented in the new design characteristics for GOW30.

The CROW defines design characteristics using a list of basic features. For each road category, the basic features, which are required for the road category, are defined textually. The list of the basic features CROW uses and what they mean can be seen in Appendix B. To show how such a road could look, drawings of ideal and minimal designs are given. These drawings for GOW50 can be seen below in Figure 1 and Figure 2. CROW stated that they want to wait to implement GOW30 in their basic features for roads document until they can learn from experience regarding the implementation of GOW30 roads (CROW, 2023).

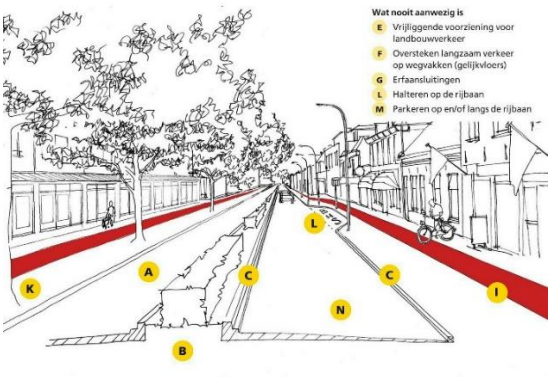

Figure 1: Ideal design GOW50 (CROW, 2012)

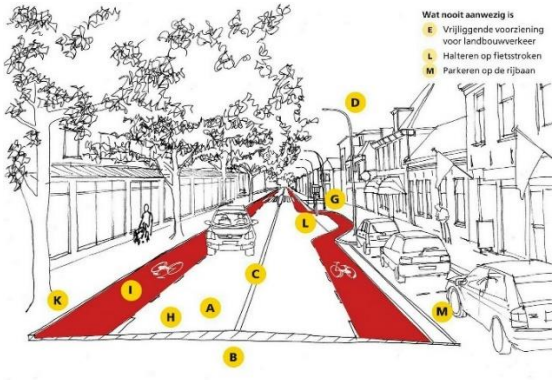

Figure 2: Minimal design GOW50 (CROW, 2012)

Since October 2023, GOW30 has also been adopted into the implementation rules regarding roads, the BABW (Uitvoeringsvoorschriften BABW Inzake Verkeerstekens, 2023). This means that starting October 2023, municipalities could legally start implementing the new road category in their road network. After the change, roads with a traffic function can have a 30 km/h speed limit. Next to that, priority rules have been changed, municipalities can now apply priority rules to 30 km/h roads. It is however important to note that implementing it is not mandatory for municipalities; they can use the new road category to decrease the speed limit of their road network to 30 km/h in parts where they want to do so.

The implementation of GOW30 roads by municipalities is closely followed by CROW and evaluated. For this, SWOV has created an evaluation system (Hettema et al., 2021). For this evaluation system, they collect information and feedback on how municipalities are implementing the road category. Since the results of municipalities will be combined, a system for evaluation has been made to ensure that all evaluations are done in the same way. In personal communication, SWOV has stated that no results are currently available. The reason given is that most municipalities have only just started implementing GOW30 in their road network. Therefore, using experience from other cases cannot be used in implementing GOW30 in municipalities. Based on the findings of these studies, CROW will adjust the design characteristics and fully implement them in their road design guidelines. CROW is therefore an interested party in this research since they would like to gather information on how to implement the GOW30 road categories in municipalities.

With the change in the BABW, GOW30 was made possible in the legal sense. The challenge for municipalities is that road users will not comply with speed limits if the design of the road is not in line with it. Therefore, implementing GOW30 legally will not guarantee that road users will adhere to the 30 km/h speed limit. As a result, road safety may not improve as desired, which is the goal of the decreased speed limit. Now, the problem for municipalities, including Enschede, is how GOW30 roads should be designed to ensure an actual decrease in travel speed by road users.

The municipality of Enschede does not see the CROW design characteristics as sufficient and immediately usable. The provisional characteristics, as provided by CROW, still give a wide range of possible road designs. This makes going through the current CROW design characteristics for GOW30 difficult and time-consuming to do for every road. This variability also makes it difficult to have a uniform road design within a municipality. Therefore, the municipality of Enschede would like to have design characteristics specific to Enschede, which consider the specific road users and stakeholders of the road network in the municipality. They would like to see a set of design options that apply to the GOW30 roads in the municipality.

A second problem the municipality sees in the CROW design characteristics is that they are made using only the traffic engineering point of view. Within a municipality, it is not enough that only traffic engineers agree with the implementation. The process of designing roads is not exclusively done by the traffic engineers. Different teams are involved in the preparation and realisation of road projects. These other stakeholders should also agree with the road design. Disagreement could lead to delays or a change in design. By involving these stakeholders earlier in the process of creating a design, these problems can be avoided.

This means a major part of this research is to involve parties that have a say in the implementation of changes in the road network. These are parties within, but also outside of the municipality and are listed below.

- **Emergency services**
    - Emergency services have requirements for roads they deem essential and are therefore stakeholders.
- **Enforcement**
    - The police must enforce the speed limits on roads, but if they do not see the speed limit as credible, they will not enforce it. Involvement is therefore important.
- **City engineers**
    - The city engineering team must approve the plans before they are executed since they oversee the civil city planning.
- **Public lighting**
    - Roads must adhere to certain lighting regulations.
- **Landscapers**
    - This team designs the surroundings of the road and is therefore a stakeholder.
- **Maintenance**
    - This team oversees the maintenance of the road and everything surrounding them, including greenery.
- **Road managers**
    - This team manages the roads themselves and is responsible for the construction.
- **Public transport services**
    - These services have certain requirements to ensure safe usage of their services.
- **Environmental specialist**
    - Roads must adhere to environmental regulations. Noise production regulations are most applicable to this research.
- **Traffic engineers**
    - This team designs the roads and is the team for which this assignment has been performed.

7 RESEARCH AIM AND QUESTIONS

This thesis research aims to develop a general design framework to support the municipality of Enschede in dealing with the implementation of GOW30. This will be accomplished by adapting the CROW framework to make it applicable to Enschede. This design framework will show multiple design options for multiple different combinations of road characteristics. Using this framework, the municipality can input the road characteristics for a GOW30 road, and the output will be a generic design for the road. This will give the designers a clear base on which to design the road, which will also be more in line with the current way of working.

Research Scope

- The design framework will only be created for GOW30 roads within the municipal boundaries of Enschede.
- Only the road network within build-up areas is part of this research.
- Already existing ETW30 roads are not considered for the research, because it is clearly stated by CROW (2021) that ETW30 roads are not intended to be transformed into GOW30.
- Industrial areas as defined by the municipality of Enschede are also outside of the scope of the research. This is because the municipality already has made plans for those roads separate from the GOW30 theme.
- The map that defines the scope of the research can be seen in Appendix C.

Research Questions

From the research objective and scope described above, three main research questions are formulated:

1. **Which roads in Enschede are categorized as GOW30 when applying the consideration framework of CROW (2021)?**

The municipality of Enschede has already gone through the process of determining the GOW30 roads in its network. However, this question remains to be answered because the existing map was not made by following the consideration framework. To answer this question, two sub-questions are formulated:

   a. How does the existing GOW30 map comply with the CROW consideration framework?
   b. What are the characteristics of the GOW30 roads in the municipality?

The output of these sub-questions helps answer the main question, which is required for moving on to the next main question.

2. **Which road design characteristics should be included or excluded in the framework for GOW30 roads in the municipality of Enschede?**

Now that it is known which GOW30 roads there are in the municipality, they would like to know how to design these. Therefore, two sub-questions are formulated:

   a. How can the design characteristics from CROW (2023) be applied to the GOW30 roads of the municipality of Enschede?
   b. Is the new design framework applicable to roads of the municipality of Enschede?

The first sub-question creates the new design framework in cooperation with the stakeholders; however, it still must be checked if it applies to the municipality. This is done by applying the design framework to a part of the network in Enschede, which is done in the second sub-question.

3. **How do stakeholders foresee the proposed implementation of GOW30 in Enschede?**

Now that there is a proposed framework, it is validated by gathering feedback from the stakeholders. These same stakeholders will also provide input for the framework, therefore having them at the end of the process will help validate the framework. This validation step should lead to a better understanding of what still needs to be done to properly implement GOW30 in the municipality.

   a. How do stakeholders of the municipality see the proposed implementation?
   b. How is the proposed implementation compared to the vision of CROW?

8 RESULTS

This study is a design project researching how the GOW30 road category can be implemented in the municipality of Enschede. This is done by creating a workable design framework for the municipality. Below, an overview of the steps that are made to reach this aim and answer the research questions is provided. After that, each step is elaborated upon by detailing the actions taken and the results obtained.

1. Use the CROW framework to reassess the existing road categorisation of the municipality.
2. Determine the characteristics of the GOW30 roads in the municipality.
3. Discuss the implementation of GOW30 roads with the stakeholders.
4. Create a design framework for GOW30 roads in the municipality.
5. Validate the design framework.

These steps follow a design cycle (SLO, n.d.). The first two steps are part of the analysis and description of the problem. The third step focuses on setting up the programme of requirements and will start devising elaborations to solve the problem. Step 4 will be the biggest part of the design process, which will finish the elaborations and realise the actual design. Step 5 is done to test and evaluate the design. Because there is already a clear view of what needs to be designed, the step to formulate a design proposal is not specifically done in the steps. The research proposal for this thesis can be seen as the design proposal.

8.1 ROAD CATEGORISATION

In this first step, a new road categorisation map is made by following the CROW framework, as seen in Appendix A. This is done for all current GOW50 roads. The existing GOW30 categorisation map was not made by following the CROW consideration framework. Instead, the traffic team assigned roads the category based on their knowledge of the roads and the concept of the GOW30 road category. Their road categorisation can be seen in Appendix C.

The first step of the CROW framework is determining the function of the road in the context of the network. This will lead to either a residential function, a traffic function, or a double function, where traffic and residential uses co-exist. Determining the function of the road is done by looking at the characteristics of the surroundings of the road. Houses being directly next to the road means a residential function, just like schools, shops, and sports facilities. A traffic function is identified mostly by looking at the entire road network. If it is an important connection between two parts of the city, it has an important traffic function.

The final identifier for a traffic road is if it is an important public transport route or traffic artery for emergency services. For this, the internal map of fire brigade emergency routes is used. Talking with said emergency services stated that, since they require the most access, using this map is sufficient for all emergency services. For public transport, the map of current bus routes in 2023-2024 for Arriva, the bus provider in Enschede, is used. They are the only public transport operator in Enschede that uses the road network, and they only provide bus services.

Identifying this for a road will lead to the function of the road. If a road has an exclusively residential function, the road category is always ETW30. If it has a double or traffic function, the next steps in the framework are followed.

There is a second step for roads with a double function. Here, the CROW framework asks the road manager to solve the double function by changing the network. This could for example be done by

changing a bus or emergency services route. For this research, it is assumed that this is not possible. This second step is therefore not performed. The third step is also only for roads with a double function. The traffic function is weighed against the residential function. Only if traffic flow is the most important function of the road, the road will get a GOW categorisation. Otherwise, it will be labelled ETW30.

Step 4a asks the question if there are reasons to set a speed limit of 30 km/h. These are, for example, schools in the area, the liveability of surrounding residents, and the ability to safely cross the road. If any of these reasons are present on a road, it should be a GOW30 road. If not, step 4b looks at if the road can be safely designed for 50 km/h. For this, road characteristics are used. These are if there is a separate cycle path, safe crossing, lane separation, and preferably no parking next to the road. For these characteristics, the first one is very strict. If no physically separate cycle path can be realised, it is a GOW30 road. The final one about the parking next to the road is not strict. Parking next to the road is preferably not present for GOW30, but it is possible. That is because current GOW50 roads often have parking present, and it would not be possible to remove all parking on these roads. These characteristics are gathered for a road and a decision is made if the road is currently safe for 50 km/h or if there is at least space for a safe 50 km/h road design. For example, on roads with a very wide median strip but without separate cycle lanes, there is space for a safe 50 km/h road design, because the space from the median strip could be used.

The last step should be to optimise the network, because of time constraints, this has not been performed in this study.

These steps are followed for all GOW50 roads in Enschede, identified through the use of a municipal map (Hillen, 2022). The roads were analysed using satellite imagery and Google Streetview. Next to that, most roads in the network were also analysed by visual inspection. Doing this for all GOW50 roads leads to a new road categorisation map which can be seen below in Figure 3. This figure shows all current GOW50 roads in Enschede within the scope of this thesis. The red roads will continue to have a GOW50 categorisation. The green roads receive a GOW30 categorisation and the brown roads an ETW30 categorisation.

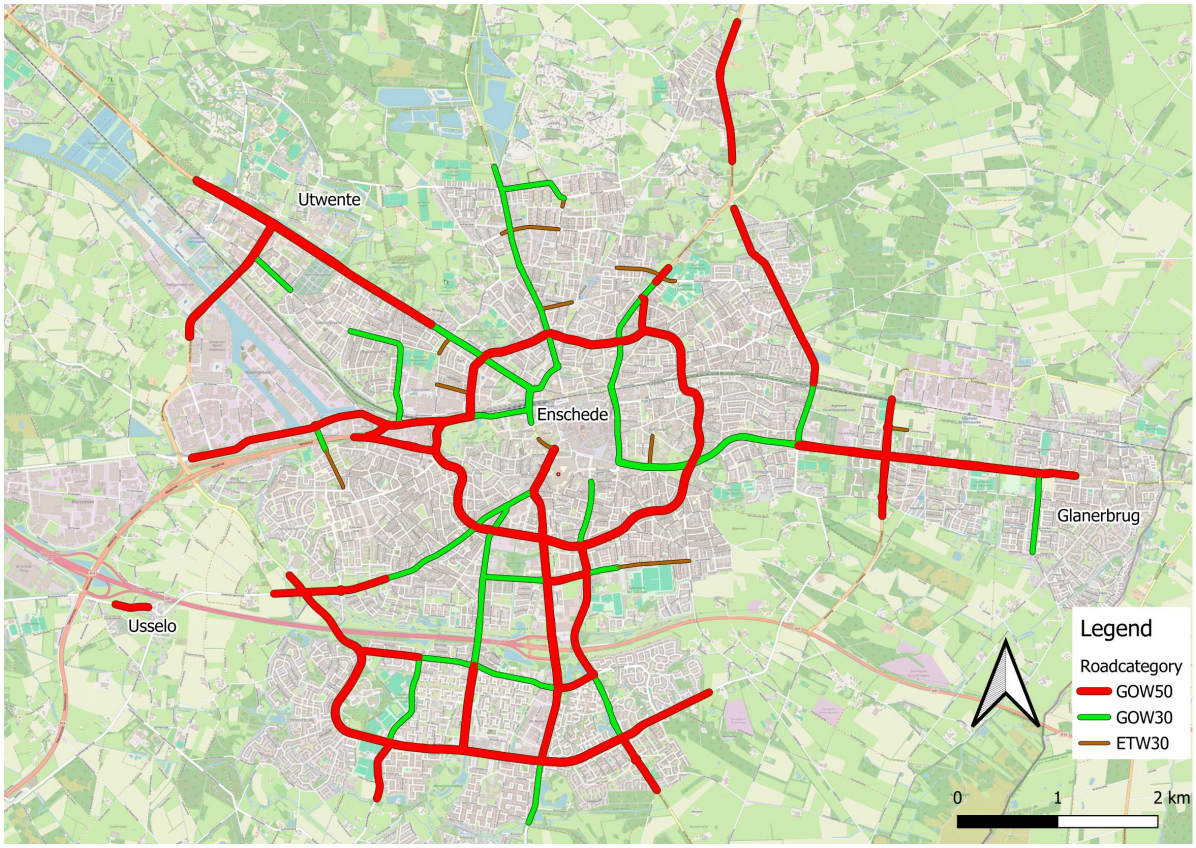

Figure 3: Road categorisation following the CROW (2021) consideration framework

The data on which this map is based can be seen in Appendix D. This table shows all GOW50 roads in Enschede and their characteristics. The reasoning used to follow the consideration framework is also in the table. The streets where the name is made bold are the ones where the categorisation following the CROW framework differs from the one the municipality made. One thing to note in this categorisation is that the entire Singel is taken as one entity. This is done because of the public space regulations of the municipality of Enschede (2024). These clearly state that the Singel should have the same design everywhere and see it as one entity.

The first iteration of the map and accompanying data has been discussed with two members of the traffic team and the differences have been discussed. These differences mostly stem from a difference in approach, and neither is right or wrong. Some alterations have been made since by re-analysing the roads again with the new knowledge about these roads. These have been presented to the traffic team of the municipality and they will use this map as a reference of how the CROW would like to see the road categorisation in Enschede. They see this map not as directly implementable because the network has not yet been optimised, but as a good basis to further improve the road categorisation. This lack of optimisation results in illogical road categorisation with a lack of structure. This can be seen in the figure where the category changes often on the same continuous road.

While most roads or road sections do have the same categorisation, there are 21 differences. 11 of these are currently 50 km/h roads or road sections that did not get a category in the existing map. These should have been re-categorised but were overlooked. 3 road(section)s got categorised as a GOW30 instead of a ETW30. This originates from a difference in opinion about the function of the road. The municipality sees them as residential, while my analysis sees them as having a dual function. The final 7 differences are differences between GOW30 and GOW50. The CROW framework gives priority to whether the road can safely be 50 km/h. If that is not the case, it completely overrules the

importance of the road for traffic. This prioritization is not present in the existing map. A second source of difference is the knowledge about the area a road(section) resides in. The municipal team might have more experience with the area. The differences due to this issue have been discussed and changes have been made, but it is possible not all reasons for 30 km/h have been discussed.

8.2 Characteristics of GOW30 Roads

During the process of categorising roads, the characteristics of all GOW50 roads have been collected and can be seen in the table of Appendix D. Since all GOW30 roads are originally GOW50 roads, all characteristics for GOW30 roads are also in this table. From these characteristics, two characteristics that determine the road design have been identified. The first is if the road is on an emergency and/or public transport route. The used vehicles for these services demand different road designs which is why CROW has made separate guidelines for these roads. The second characteristic is if the road already has separate bicycle lanes. CROW (2023) states that getting rid of them does not make sense since it only decreases traffic safety for cyclists. Therefore, there will be an option with and an option without separate bicycle lanes.

8.3 Stakeholder Discussions

The next step in the design process involves gathering input from the stakeholders on the design characteristics for GOW30. These are the teams listed in Chapter 6 that have a say in the implementation of changes in the road network. The CROW framework is discussed with them including their problems, wishes and demands for the implementation. This step will make sure that the to-be-created framework will have sufficient support from the stakeholders.

For these discussions, the design characteristics of CROW (2023) are used as a basis. These are basic characteristics used for all road categories and four additional road section characteristics. These are lane width, road image, facilities for emergency services and loading and unloading. Intersections, transitions, and signage for GOW30 roads are also discussed. For each stakeholder topics of interest to the stakeholder are discussed. Alongside this selection of topics, stakeholders are asked if they have any other remarks that should be included in the standard design. This has resulted in three additional road characteristics, which are pavement, materials, and corner radius. The definitions of all road characteristics discussed with the stakeholders are found in Appendix B.

This chapter discusses the main takeaways from each stakeholder and how their input translates to design characteristics. An overview of the input gathered from each stakeholder discussion can be seen in Appendix E.

The police were consulted first to see what their needs were to enable enforcement of the 30 km/h speed limit on GOW30 roads. They advocated for clarity and following the CROW guidelines would make sure the roads are enforceable. Therefore, the CROW guidelines are used as a basis for the framework.

The city engineers focussed on structural integrity, constructability, and sustainability of road materials. While the structural integrity of the roads is out of the scope of this research, the other points have been considered. This has resulted in minimizing material transitions in the surfacing and length marking characteristics. Choosing standard materials and elements for the road design has been implemented by adding a characteristic for materials. The road managers also mentioned the structural integrity and sustainability of road materials.

The public lighting specialist only gave input for the public lighting design characteristic. For that, the TOR of Enschede must be followed. The specialist did offer to calculate the average positioning between poles. This has been used directly in the public lighting characteristic of the design framework.

Creating greenery in the road view was the main point of the landscapers. They did mention that creating a standard for greenery is not possible in Enschede as there is a different vision for each road or area in the city. The creation of greenery has been incorporated into the road image characteristic. Next to that, the idea of having parking on the same elevation as the pavement was also brought up in this interview. This has also been incorporated into the design framework by specifying the parking characteristic.

Sustainable materials and elements also came back in the interview with the maintenance team. For ensuring easy maintenance they advocated for common sense when designing it. They also advocated for large plots of robust greenery instead of multiple small plots, which has been implemented in the road image characteristic.

The emergency services pressed the importance of bus-friendly alignment and design. If a road is designed for a bus, the emergency services can also make use of it comfortably. This concerns the alignment characteristic. A major point of the ambulance team was the surfacing of the road. Instead of open pavement, they preferred asphalt. An option for asphalt roads has therefore been added in the surfacing characteristic.

The environmental specialist did not provide input that should be included in the main design framework. The specialist did advocate for a small paragraph pointing out the regulations regarding noise, which has been added.

Asphalt surfacing preference was also expressed by public transport services due to its durability and noise reduction benefits. For other design elements, they referenced the CROW guidelines for designing roads for public transport purposes. This means plateau and speed bump design in the alignment characteristic, but also the road width. This has all been implemented in the design framework.

Finally, the traffic engineering team advocated for the use of asphalt on main bicycle routes. They also suggested length markings for asphalt roads. These markings give the impression of narrower lanes to help reduce vehicle speeds. These two additions are also seen in the design framework in the surfacing and length marking characteristics.

An overview of the stakeholders and which design characteristic they gave input on can be seen in Appendix F.

8.4 The Design Process

Following the stakeholder discussions, the design framework for GOW30 roads in Enschede is created. The motivation behind each design characteristic can be found in Appendix G.

The design framework for GOW30 in Enschede is shown below. It consists of two parts. The first is the decision tree in Figure 4. The second is the list with all road characteristics and their different options. The way of working is having both parts next to each other and starting by following the decision tree. Making the decisions results in which option of the design characteristic should be used for the specific road. If the decision tree is followed completely, all design characteristics with multiple options are

specified. Going through the entire list of road characteristics will then result in a list of characteristics a specific road should have. These characteristics are a guideline, and deviations are possible.

After the road characteristics list, some additional notes to keep in mind when following the design framework are presented. Finally, there are some atmospheric impressions of what several types of GOW30 roads could look like.

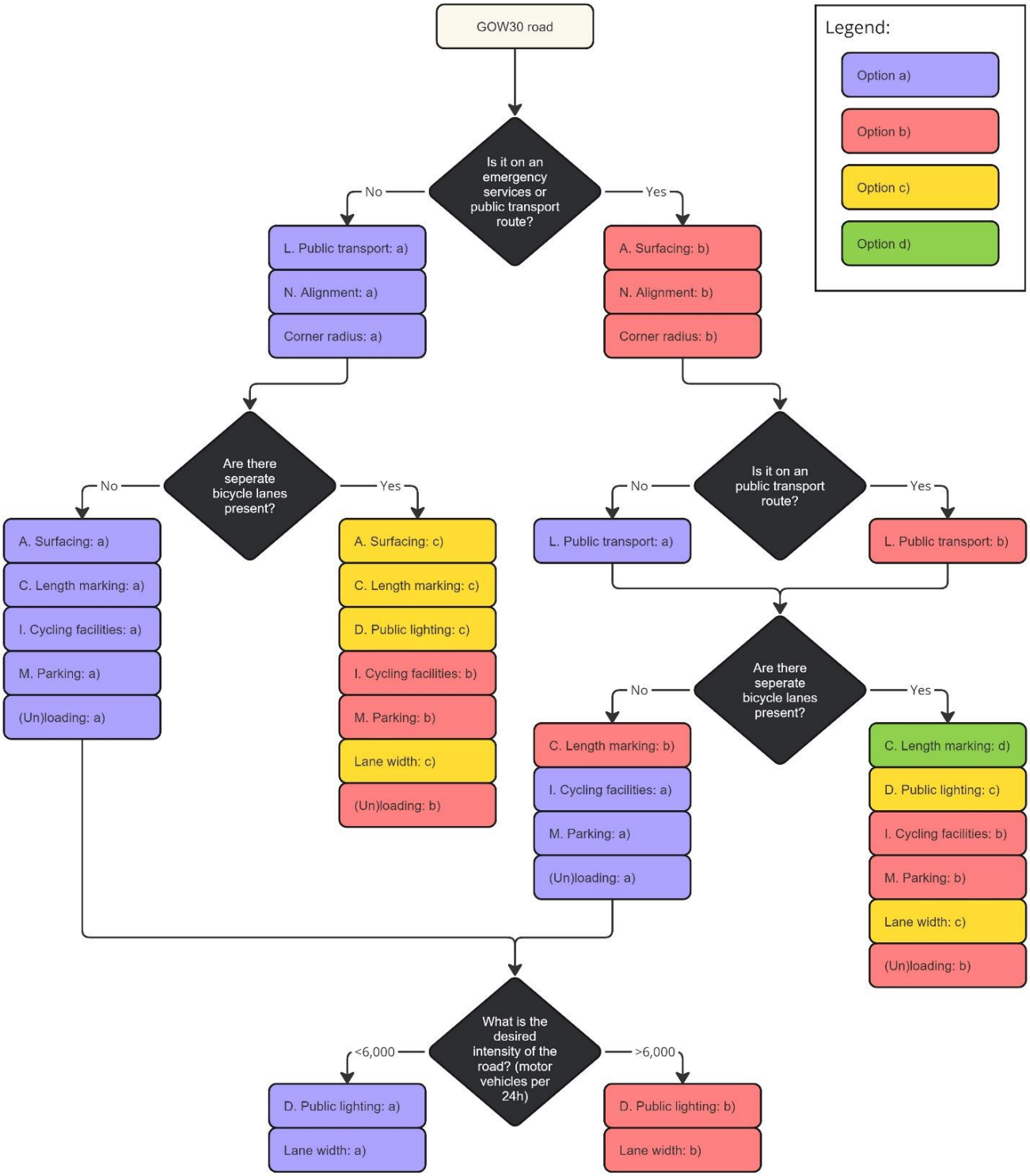

Figure 4: Decision tree for basic design features of GOW30 roads.

A. Surfacing

a) Apply open pavement over the entire cross-section in the form of baked clinkers. Except when the road is on a “doorfietsroute” or regional cycle route. These routes are determined in the Fietsvisie Enschede 2030 (Groenewolt & Lems, 2021) and should have asphalt bicycle lanes.
b) The main surface of the road will be asphalt. Preferably using a different colour or texture than the standard asphalt used on GOW50 roads.
c) Apply open pavement over the entire cross-section in the form of baked clinkers.

B. Physical lane separation

No physical lane separation (CROW, 2023).

C. Length marking

a) Only apply length marking for bicycle lanes. Apply forgiving kerbstones alongside bicycle lanes.
b) Apply length marking for bicycle lanes. Apply forgiving kerbstones alongside bicycle lanes. Use different coated/coloured asphalt for a narrow central strip. This will create two narrow track runners. This central strip can also be made by applying a clinker print on the asphalt.
c) No length marking. Apply forgiving kerbstones alongside lanes.
d) Apply forgiving kerbstones alongside lanes. Use different coated/coloured asphalt for narrow central and side strips. This will create two narrow track runners. These strips can also be made by applying a clinker print on the asphalt.

D. Public lighting

a) 4-meter light poles, currently used for ETW30. Placed on alternating sides alongside the road. Placement conforms to TOR Chapter 5 (Gemeente Enschede, 2024). Distance between poles depends on road width, as seen below in Table 1.

Table 1: Distance between poles for low-intensity GOW30 roads

Road width	Average distance between poles
5.9m	36m
6.4m	35m
6.9m	34.5m
7.4m	33.5m
7.9m	32.5m
8.4m	31m

b) 6-meter light poles, currently used for GOW50. Placed on one side of the road, with, on average, 40 meters separating the poles.
c) 4-meter light poles, currently used for ETW30. Placed on alternating sides alongside the road. Separate lighting on the separate bicycle lanes might be necessary if the light is obstructed or the distance to the road itself is too far. Placement conforms to TOR Chapter 5 (Gemeente Enschede, 2024). Distance between poles depends on road width, as seen below in Table 2.

Table 2: Distance between poles for GOW30 roads with separate bicycle lanes

Road width	Average distance between poles
5.8m	36m
6.5m	35m

E. Agricultural traffic provision

No special provisions for agricultural traffic (CROW, 2023).

F. Slow traffic crossings on road sections

Bundled and safe crossing on plateaus when possible. If it is not possible to put the crossing on an intersection, include attention-raising measures using colour, and horizontal and/or vertical alignment. Conform to point N.

G. Yard connection to the roadway

Yard connection to the roadway is allowed (CROW, 2023).

H. Mixing traffic types

Motorised, agricultural and motorbike traffic is allowed on the roadway. Bicycles and moped riders ride on bicycle lanes or separate bike paths. Pavement is present for pedestrians (CROW, 2023).

I. Cycling facilities

a) Bicycle lanes are present on the road. Minimal width of 1.75 m, ideal width of 2.2 m, in red colour (Gemeente Enschede, 2024; CROW, 2023).
b) Separate bicycle paths are present. The minimal width is 2.5 meters for a 1-way path and 3.5 meters for a 2-way path. The surface should be red (Gemeente Enschede, 2024).

K. Obstacle distance

Use standard for ETW30 roads as determined in the TOR (Gemeente Enschede, 2024). Minimize the number of obstacles near roads.

L. Public transport stops (bus/tram)

a) Not present.
b) Halt on the road. If present, the bicycle lane should be redirected around the stop, conform detail 32 of the TOR (Daniels, 2023). If that is not possible. Use detail 31 of the TOR (Daniels, 2023), make sure to interrupt the bicycle lane. Apply a local overtaking ban using signs and a continuous line in the middle of the road.

M. Parking

a) Preferably not present, but longitudinal parking is safely possible when extra scare and exit lane between the bicycle lane and parking box. This extra lane should be 50 cm wide (CROW-Fietsberaad, 2016). The parking spots will be located on the same elevation as the pavement using the forgiving kerbstones. The material will be semi-open hardening like grass concrete tiles to differentiate it from the pavement. The dimensions of the parking spots conform to the TOR Chapter 4 (Gemeente Enschede, 2024).
b) Preferably not present, but longitudinal parking is safely possible. The parking spots will be elevated using the forgiving kerbstones. The material will be semi-open hardening like grass concrete tiles to differentiate it from the pavement. The dimensions of the parking spots conform to the TOR Chapter 4 (Gemeente Enschede, 2024).

N. Horizontal and vertical alignment

a) Alignment uses the same standards as ETW30. Vertical alignment on intersections in the form of 12 cm plateaus with a different colour. Prefab concrete elements are used as ramps. For the start of the plateau, the 12 cm 30km ZONE on detail 24 of the standard details of the TOR (Daniels, 2023) is used. The minimum length of the plateau is 3 meters. In long stretches without side connections, speed reduction measures need to be present with a minimal spacing of 70 and a maximal spacing of 100 meters (Gemeente Enschede, 2024). These can be in the form of the plateaus as described above, however, if there is no space for a plateau, a speed bump can be put into place. For this, the 8cm 30km ZONE speed bump on detail 23 of

the TOR (Daniels, 2023) is used. For horizontal alignment, avoid using chicanes and instead use narrowing along the full width.

b) Alignment uses the same standards as ETW30. Vertical alignment on intersections in the form of 8 cm plateaus with a different colour. Prefab concrete elements are used as ramps, which are 2.40m long. For the start of the plateau, the bus-friendly 8 cm 30km ZONE on detail 23 of the standard details of the TOR (Daniels, 2023) is used. The minimum length of the plateau is 7 meters (CROW, 2007). The plateau should also continue 7 meters from the road axis to the intersecting road if a bus needs to make that turn. In long stretches without side connections, speed reduction measures need to be present with a minimal spacing of 70 and a maximal spacing of 100 meters (Gemeente Enschede, 2024). These can be in the form of plateaus, however, if there is no space for plateaus, a speed bump can be put into place. For this, the standard Gumacon bus-friendly speed bump is used. These need to be put on straight parts of the road. For horizontal alignment, avoid using chicanes and instead use narrowing along the full width. Make sure the alignment is also bus-friendly by, for example, making it overridable and by considering the turning radius.

Road image

Create a varied road view. This is done in the primary view by changing the roadway itself. Physically using horizontal and vertical alignment and visually using colours and patterns. In the environment surrounding the road, the secondary view, this is done by bringing varied robust greenery close to the road and making sure there is no pattern in the street view. With creating greenery, keep maintenance in mind. Refrain from using a lot of small patches of greenery. Big patches of greenery are easier to maintain. Greenery located adjacent to the road should be maintainable without obstructing the road. This means placing a hedge right next to the road should be avoided.

Intersections

For intersections, the preferred intersection forms for GOW30 roads from CROW (2023) are used. These can be seen in Appendix H. To create a varied road view, plateaus are preferred. Especially for public transport routes.

Transitions

For transitions to different road categories, the basic characteristics for transitions between road categories on road sections from CROW (2023) are used. These can be seen in Appendix I.

30 km/h signs

When entering a GOW30 road, the maximum speed of 30 km/h is indicated by a begin zone 30 sign. Leaving a GOW30 road is indicated with an end zone 30 sign. Except when going from a GOW30 to an ETW30 road, since the 30 zone continues. The current signage of ETW30 remains the same.

Lane width

a) The small profile for roads with bicycle lanes made by CROW-Fietsberaad (2016) is used as a base. The profile has the width of the bicycle lanes between 1.75 and 2.2 meters. The centre runner is between 2.2 and 3.8 meters. Then between the centre runner and the bicycle lanes, there is 10 cm for lining. The total width of the road will then be between 5.9 and 8.4 meters. This road profile can facilitate a maximum intensity of 6,000 motor vehicles per 24 hours. 6.5 meters is the minimum road width for public transport purposes, which is the same as for ETW30 (CROW, 2020).

b) The wide profile for roads with bicycle lanes made by CROW-Fietsberaad (2016) is used as a base. The profile has the width of the bicycle lanes between 1.75 and 2.25 meters. The centre runner is between 4.8 and 6 meters. Then between the centre runner and the bicycle lanes, there is 10 cm for lining. The total width of the road will then be between 8.5 and 10.7 meters. This road profile can facilitate a maximum intensity of 10,000 motor vehicles per 24 hours (CROW, 2023).
c) The minimal width is 5.8 meters for the whole road. 6.5 meters is the minimum lane width for public transport purposes, which is the same as for ETW30 (CROW, 2020).

Loading and unloading

a) Loading and unloading outside car lanes and bicycle lanes (CROW, 2023).
b) Loading and unloading outside car lanes and bicycle lanes. If this is not possible, it could be done on the roadway (CROW, 2023).

Pavement

Pavement alongside the road is present. At least 1.2 meters, for short narrowing, i.e. light poles, 0.9 meters is acceptable (Gemeente Enschede, 2024).

Materials

Use materials and elements that are standard for the municipality and used more often.

Corner radius

a) Optimally 10 meters (Gemeente Enschede, 2024).
b) Optimally 12 meters (Gemeente Enschede, 2024).

Surfacing options a and c use open pavement over the entire cross-section. If this is not realizable, an alternative with asphalt could be made. This alternative will take length marking option b, option c should be taken if there is a separate bicycle lane. An example of this is illustrated in the CROW guidelines (CROW, 2023).

For public lighting, the placement of the light poles should always be checked and is dependent on the surroundings of the road. The given light pole distance is only an average when you do not have to consider the surroundings.

Another important aspect is noise. Changing the road network by decreasing the maximum speed, applying open pavement, and adding vertical alignment influences the noise produced by vehicles on the road. How much noise a road is allowed to produce is determined by the “omgevingswet”. All roads should be compliant with this law. To ease this process, a traffic environment map is in development for the municipality of Enschede. The proposed design should be put into this map, which will show if the proposed design fits within the noise limits. The two most important aspects of the road will be A surfacing and N alignment. For A, instead of baked clinkers, silent clinkers can be used to decrease noise. For N, locations of vertical alignment can be changed or instead of a 12 cm version, the lower 8 cm version can be used. However, since this traffic environment map is still in development, the effects of these changes cannot be guaranteed.

Following this design framework leads to a basis for the road design. Below are three examples of what different GOW30 roads could look like. The letters in the figures correspond to a basic design feature. Figure 5 shows a GOW30 road which is not an emergency or public transport route, without separate bicycle lanes and with a desired intensity lower than 6,000 motor vehicles per 24h. Going through the decision tree for this road results in design characteristics that can be seen in the figure.

The road has an open pavement across the entire cross-section, forgiving kerbstones alongside the bicycle lanes. 4-meter light poles alternating from side to side can also be seen, with varied greenery in big green spaces in between the light poles. Longitudinal parking on grass concrete tiles is present on the same elevation as the pavement. Finally, the total lane width is 6 meters.

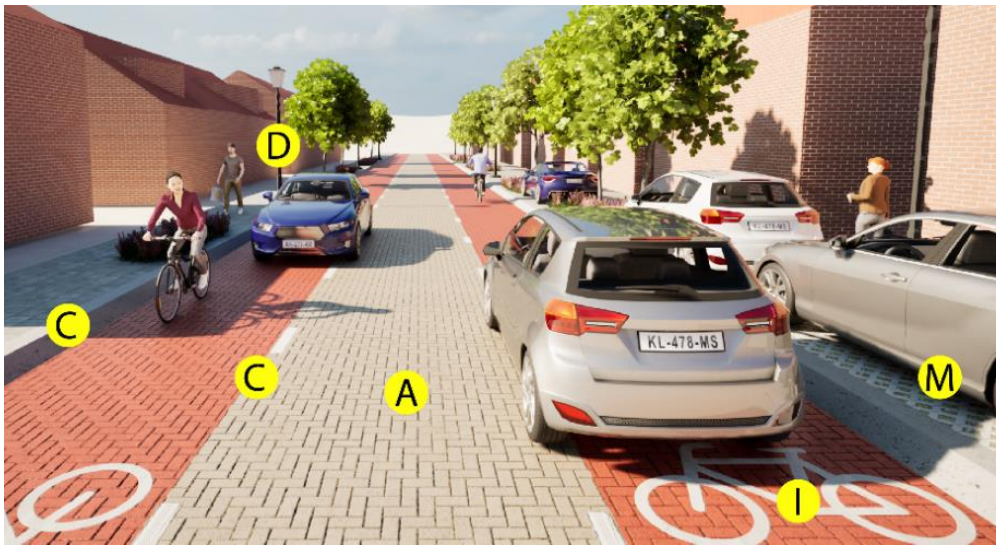

Figure 5: Atmosphere impression for a narrow GOW30 road.

Figure 6 shows a GOW30 road which is a public transport route without separate bicycle lanes and with a desired intensity higher than 6,000 motor vehicles per 24h. The road characteristics are a result of following the design framework.

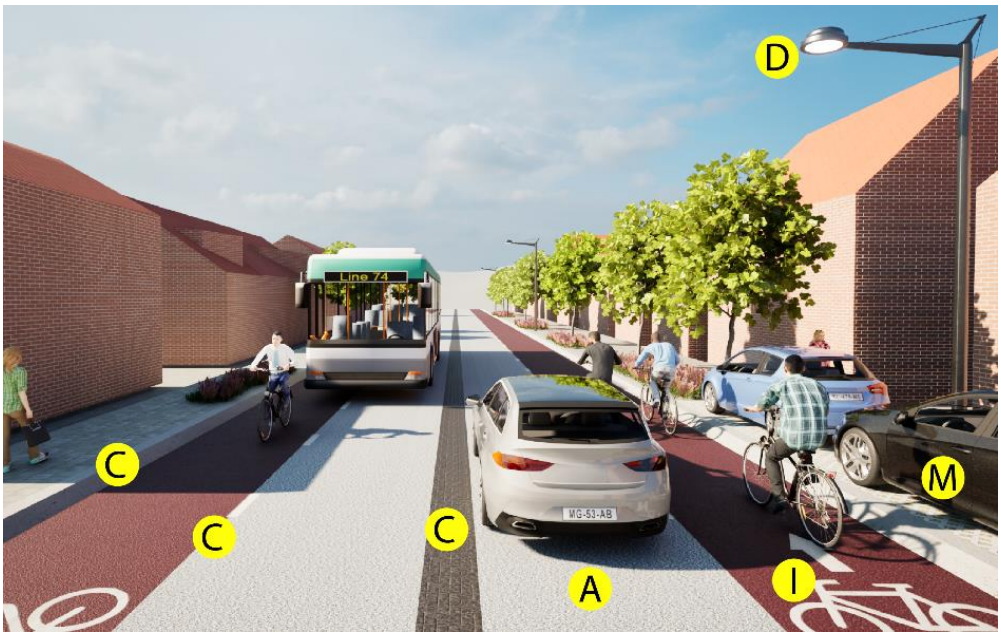

Figure 6: Atmosphere impression for a wide GOW30 road.

Figure 7 shows a GOW30 road which is not an emergency or public transport route but does have separate bicycle lanes.

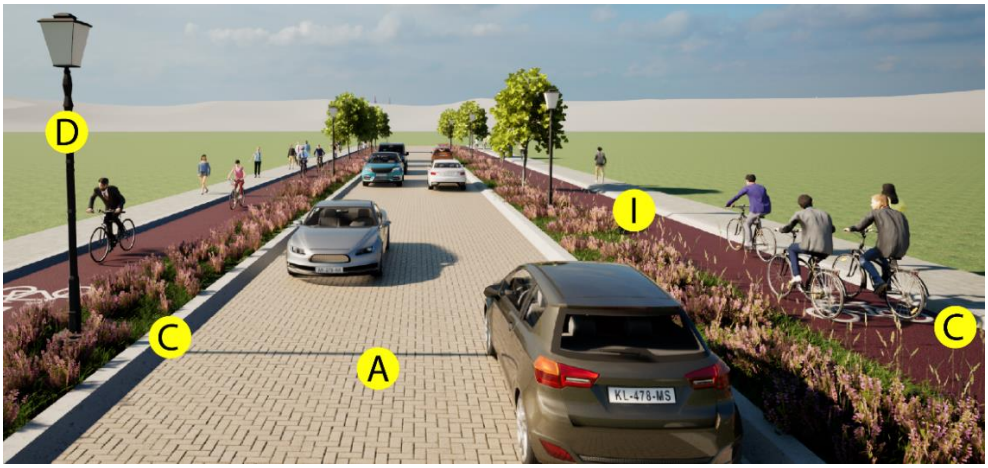

Figure 7: Atmosphere impression for a GOW30 road with separate bicycle lanes.

Following the design framework will result in design characteristics to use as a basis when designing GOW30 roads. This framework does not give an immediately buildable road design. For example, the exact locations of public lighting or the construction beneath the road still need to be decided in cooperation with the respective teams. It shows which road design characteristics are important for GOW30 in Enschede and gives design options that are widely supported by the stakeholders of the road network.

8.5 Validation

The validation of the design framework is done in three parts. First is validation through application, second is validation through stakeholders and third is validation through the CROW. Each part is discussed below. Finally, a revised design framework is proposed.

Validation through application

In this part, the design framework is validated by applying it to a GOW30 road, as determined in Step 1. This application is performed by a traffic engineer from the municipality. This engineer used the design framework on the Jupiterstraat. This road is on the list for major maintenance and has been identified as a GOW30 road in both categorisations. Feedback was given on the usability of the design framework. Alongside the usability, the design characteristics resulting from the design framework were also evaluated. The focus was if they were logical and if they would be used in road design.

The choices in the flowchart of the design framework for the Jupiterstraat are the following. It is a major route for emergency services, it is on a bus route, there are no separate bicycle lanes, and the desired intensity of the road is more than 6,000 motor vehicles per 24 hours. The resulting design characteristics would make the basic design of the road look like Figure 6.

In terms of usability of the design framework, the traffic engineer stated that the flowchart and method of determining the design characteristics for the road were well structured. The traffic engineer did find the results of the framework mostly logical. However, there is one questionable design characteristic. That is the road width, which when strictly following the design framework, should have a minimal width of 8.5 meters. The Jupiterstraat is currently 8 meters wide. This would mean that the road would get wider while lowering the maximum speed limit. This seems counter-productive since making a road narrower helps create a credible speed limit and widening it does the opposite (CROW, 2023). In daily practice, this road widening will not happen when the speed limit is decreased from 50 to 30 km/h.

Validation through stakeholders

The second part of the validation step is sending the resulting design framework back to the stakeholders and asking if they feel that their input has been properly implemented and if there are problems with the proposed framework. The framework has been sent to all the stakeholders that have given input in the chapter 8.3. The traffic engineers were not included in this because they had already given feedback in the previous part of the validation. The environmental specialist team was also excluded because their input resulted in an additional remark at the end, rather than being included in the main framework. Moreover, they did not deem it necessary to validate their input.

All stakeholders stated that their input has been properly implemented in the proposed framework. Some stakeholders did have some additional remarks which will now be discussed.

The landscapers did not fully agree with the statement under design characteristic 'road image' that placing hedges right next to the road should be avoided. The landscaper noted that it could be applied to create a barrier between the road and a separate bicycle lane. For maintenance of these hedges, temporary barriers and signs are currently placed, making maintaining the hedges doable. This existing work method, combined with a decreased speed limit from 50 to 30 km/h makes the landscapers state that these hedges can be placed as a barrier between the road and a separate bicycle lane.

The emergency services stated they would like to see an added reference to their handbook about firewater supply and accessibility (Brandweer Nederland, 2020). This addition is meant to notify road designers that this handbook could be used as a further reference for what the emergency services want.

The stakeholders see the proposed implementation as acceptable, workable and a good basis for designing GOW30 roads in Enschede. Some small additions have been provided, but these will not drastically change the design framework.

Validation through the CROW

The last validation step is discussing the design framework for GOW30 in Enschede with CROW. This is done to validate if the implementation method is along the lines that CROW envisioned. For this, a meeting was held at the CROW office in Utrecht. In this meeting, all design characteristics in the design framework were discussed. The characteristics that CROW gave input for during the meeting will be discussed below. Next to this, the stakeholder group was discussed, and CROW stated that all important local stakeholders had been involved in the creation of the framework.

For surfacing, CROW understood the choice of the three different options. In option a), where some bicycle routes should have asphalt, they mentioned they want to start new research into the comfort of cyclists on different surfaces. The material quality and building methods have changed significantly since the last study. However, the framework is in line with the current guidelines from the CROW.

For the length markings, it is not necessary to apply forgiving kerbstones alongside lanes without bicycles on them. The kerbstones are mainly meant for bicycles and not for motorised vehicles. It is of course still an option to apply the forgiving kerbstones alongside the lanes for emergency vehicles. The kerbstones do offer vehicles a quick way to get out of the way, but it does not have to be standard on every GOW30 road.

The CROW was not aware that the low 4-meter ETW30 light posts are not realistic for the wide-road width option.

There are some differences in road width standards between the CROW and the TOR of Enschede. According to CROW, this is understandable because the CROW guidelines are for the entire country and roads, and its users can be different in Enschede than the national average.

Regarding obstacle distance, CROW referred to their vehicle profiles. In the framework, the TOR is used, but this could be checked with the profiles of the vehicles that will use the roads. A quick check did show the TOR corresponding with the CROW guidelines.

For public transport stops, it is a risk to not redirect the bicycle lane around the stop. Bicycles will then often try to go around the bus instead of waiting, which can create dangerous situations. However, the framework gives a clear preference which is in line with the CROW. An exemption for bus stops where the bus can wait for an extended period instead of just stopping is not in the framework. These stops should always be on a separate lane to not disturb the traffic flow. The CROW did not see adding this to the framework as necessary since it is a standard practice that public transport companies will always pay attention to, and it will only clutter the framework.

Parking is fine in the way described in the framework. Diagonally backwards parking is also allowed for GOW30, but since that is not used in the TOR of Enschede, it makes sense that this option is missing in the framework.

CROW agrees with the vertical alignment standard of the framework. But to add to that, CROW would like to demotivate the usage of horizontal alignment. They have seen that horizontal alignment often leads to unsafe situations because bicycles suddenly must share their room with cars. Next to that, it does not show a decrease in speed, this is also the case for full-width narrowing.

For intersections, the preference for plateaus was logical. However, CROW prefers roundabouts if there is space for them. Roundabouts cause a decrease in speed for all users and match the intensity of GOW30 roads.

The finding about the road width gathered by applying the framework was also discussed with the CROW. They agreed that this widening of the road was not logical, and they stated that the intensity is quite arbitrary and should not be used the way it is now in the framework. The CROW vastly preferred the narrow GOW30 option, and the wide option was a result of a compromise. When the evaluation of the implementation of GOW30 is finished, the CROW expects that the wide option will not make the final guidelines because it does not sufficiently create a credible speed limit. For this design framework, the CROW opted that if a road has an intensity higher than 6,000 motor vehicles per 24 hours and is a high-intensity bus route, the category of the road should be reevaluated. This could mean that the road requires separate bicycle lanes, which could result in a GOW50 category.

All the design characteristics help with creating a credible speed limit, but CROW admitted that they do not currently know exactly how much effect an intervention has on that credibility. These effects will be gathered from the evaluation studies for GOW30. Based on these results, CROW will make the design characteristics for GOW30 their definitive guidelines.

While the CROW would like to see some alterations, they see the proposed implementation as being in line with their vision of GOW30 and as a valuable insight into how municipalities deal with implementing GOW30.

Overall, the stakeholders see the proposed implementation of GOW30 in Enschede as acceptable and workable. This means the design framework is a valid method for the stakeholders asked and in the scope of this research. The framework is seen as a good basis for designing GOW30 roads. However,

it should be seen as a basis guideline and deviations are inevitable. It is also only valid for the municipality of Enschede since only their stakeholders have been involved.

Revision

A revised design framework for GOW30 in Enschede has been made following the validation. This can be seen in Appendix J. The changes compared to the previous design framework are listed below, these come directly from the validation above.

- A reference to the handbook for emergency services has been added as a note at the end.
- The sentence in 'road image' that hedges should be avoided has been removed since the sentence before already covers the issue of maintenance.
- The advice for forgiving kerbstones alongside roads with separate bicycle lanes has been made optional in C.
- In N. the advice about horizontal alignment has been replaced by text demotivating the use of horizontal alignment.
- For the lane width, references to the intensity have been removed. In the wide option, it is stated that option c) with separate bicycle lanes should be the preferred option and only if that is not possible, the wide option should be used. In the flowchart, only the combination of intensity higher than 6,000 and being on a high-intensity bus route gives the option for the wide road. But first, the choice for road category should be reconsidered.

This final revision meets the research aim of developing a general design framework for how the municipality can deal with GOW30. It builds on the CROW framework and ensures support from the stakeholders.

9 DISCUSSION

In this research, many choices were made that impacted the results. This chapter discusses these choices chronologically as they were encountered in the execution of this research.

The first step of this research, the categorisation, was meant to show an objective map of GOW30 roads according to the CROW consideration framework. This objectiveness has proven difficult. Some choices in the consideration framework are objective, like if buses use it. Others are subjective, for example, if there are liveability reasons to limit the speed to 30 km/h. The term space for safe 50 km/h is also subjective. While my analysis sees a wide green median runner as a possible space for the road, others do not see this as space a road could claim. This makes the map created for Enschede not definite and should be seen as an indication of how the categorisation could look when following the CROW consideration framework.

In the third step of the research, information is gathered from stakeholders, which is in essence subjective. It is only a reflection of what the stakeholders have mentioned. Many stakeholders have been talked to, but a different selection of stakeholders, or even different representatives from the team, could lead to different results. However, as CROW stated in their validation, they deemed the group of stakeholders involved in this research as valid. All stakeholders also mentioned that all their input was well implemented, and they were positive about the resulting design framework. Therefore, while subjectiveness is a variable that cannot be disregarded in this research, the result is still valid for the scope and aim of this research.

In Step 5 of this research, the created design framework was validated in three ways. The first is validation through applying the framework on the road network of Enschede. This was performed on a single road. This means not all design options following the design framework have been validated through the application. Six possible combinations of design characteristics result from following the framework. This was not done because of time constraints. Doing so for all combinations could mean that more problems with the framework were found. However, this would remain to be the case even if all combinations were applied. There could always be a road that does not fit into the framework, or where the resulting design characteristics are not logical. The framework is therefore only a guideline and can help in designing GOW30 roads in Enschede. All stakeholders agreed that the proposed design framework is valid for this use.

The whole design cycle has also been followed once in the execution of this research. The stakeholders could give input on two occasions. The first one was the initial input for creating the framework and only the second one was feedback on the framework. This means the revised design framework has only gone through one feedback loop. The biggest difference in the framework is the change to the lane width. This directly follows the input received from the CROW. But that change has, for example, not been checked with the public transport services. They might not deem this change acceptable.

10 CONCLUSION

Now that all results have been gathered, the conclusions and answers to the research questions formulated in Chapter 7 will be presented in this chapter.

Figure 3 in Chapter 8.1 shows which roads in the municipality of Enschede will receive the GOW30 categorisation when the CROW considering framework is applied. The accompanying table in Appendix D provides the differences between this categorisation with the one made by the municipality. The differences mostly stem from roads forgotten in the existing map and from a different approach for reasons for 30 km/h and space for a safe 50 km/h design. Most categorisations are in line with the CROW consideration framework. This table also shows the characteristics of all GOW50 roads in the municipality. Since all GOW30 roads are originally GOW50 roads, all characteristics for GOW30 roads are also in this.

By gathering input from the stakeholders of the road network, as presented in Chapter 8.3, a design framework is created, which is presented in Chapter 8.4. This framework is how the design characteristics from the CROW (2023) can be applied in Enschede while ensuring support from the stakeholders. The applicability of the framework on the roads of the municipality of Enschede is only checked for a single road. This has shown that the road width design characteristic does not apply to the road of Enschede, but the other design characteristics are applicable. The list of characteristics that need to be included resulted in the list as proposed in chapter 8.4. No characteristics have been excluded that were originally proposed.

This original design framework has been validated by gathering feedback from the stakeholders. The stakeholders see the proposed implementation as acceptable and workable. Some small additions have been provided, but these will not drastically change the design framework. It has also been validated with the CROW. While the CROW would like to see some alterations, they see the proposed implementation as being in line with their vision of GOW30 and as a valuable insight into how municipalities deal with implementing GOW30. All stakeholders see the proposed implementation of GOW30 in Enschede as acceptable and workable, although some wishes for alterations have been put forward.

These wishes have been processed into a revised design framework for GOW30 in Enschede, shown in Appendix J. This final revision meets the research aim of developing a general design framework for how the municipality can deal with GOW30. It builds on the CROW framework and ensures support from the stakeholders. However, it is important to note that this framework has only gone through one validation loop and the revisions have not been validated by the stakeholders.

This framework gives the municipality the ability to easily create a list of design characteristics to use as a base for designing a GOW30 road. The design framework allows for multiple combinations of road characteristics and provides three atmospheric impressions of how a GOW30 road could look. This will give the designers a clear base on which to design the road, which will also be more in line with the current way of working. The framework is also widely supported by the stakeholders of the municipality who stated the framework is a good basis on which to design GOW30 roads.

11 RECOMMENDATIONS

This chapter presents the recommendations gathered from the results and execution of this thesis.

As stated in the discussion chapter, the revisions made to the framework based on the validation have not gone through another feedback loop. Discussing the revisions with the stakeholders could further guarantee support from the stakeholders. Especially the road width is a design characteristic that could have a major influence on some stakeholders like emergency services.

Next to that, the framework has only been applied to a single road. Applying it on more roads will lead to better validation. This use of the framework could lead to identifying more problems and will lead to a better understanding of how widely applicable the framework is. The framework can then be improved based on this testing. Which will in turn ensure that the framework is more applicable to the network of the municipality of Enschede. Gathering feedback on applying GOW30 is also a focus point for the CROW. They want to use that experience to improve their provisional design characteristics and include GOW30 in their basic road characteristic guidelines. Findings on the application of GOW30 should therefore also be communicated to the CROW. This will ensure the knowledge gained in the municipality of Enschede can be used on a national level.

Multiple stakeholders also stressed the importance of the structural integrity of the new road category. The standard open pavement road is not used to the intensities of GOW roads. Combining this with the increasing weight of vehicles, the current practices for road construction could prove to be insufficient. This should therefore be further elaborated on before GOW30 roads are implemented.

The road categorization for the municipality of Enschede also needs to be updated. This could be done by going through the differences between the two categorisations shown in Appendix D and deciding which categorisation the network should have. Because of the subjective elements of the CROW consideration framework, their analysis might differ from the one shown in this report. The network should also be optimised and made logical. Finally, road categorization must go through the political municipality council before it can be implemented. However, a proper analysis that is based on national guidelines will help provide a strong substantiation for the road categorization of the municipality of Enschede.

Only implementing this design framework when developing GOW30 roads does not guarantee a credible speed limit. The rest of the network surrounding the GOW30 road also helps in the credibility. Therefore, the proposed changes to the ETW30 and GOW50 road category standards as given in the CROW framework (CROW, 2023), should also be applied to the existing road network.

However, even then, the credibility of the speed limit is not guaranteed. This is because the effect the design characteristics have on the credibility is unknown. Research into quantifying the effects of the different design characteristics would greatly improve the ability of road designers to create a credible speed limit. This would also help in stakeholder management because having proof a certain intervention does not help with the credibility of the speed limit could ease discussions.

Finally, many standards are currently not up to date with the new road categorisation. These should be updated to further support and facilitate the usage of GOW30. The handbook by the fire brigade (Brandweer Nederland, 2020) does not include their wishes for GOW30 road. Before the design framework can be implemented in Enschede, the TOR (Gemeente Enschede, 2024) also needs to be updated. This document currently does not support all design characteristics as proposed in the design framework. The municipality has received a list of points in the TOR that are not in line with the design framework.

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13 APPENDICES

13.1 APPENDIX A

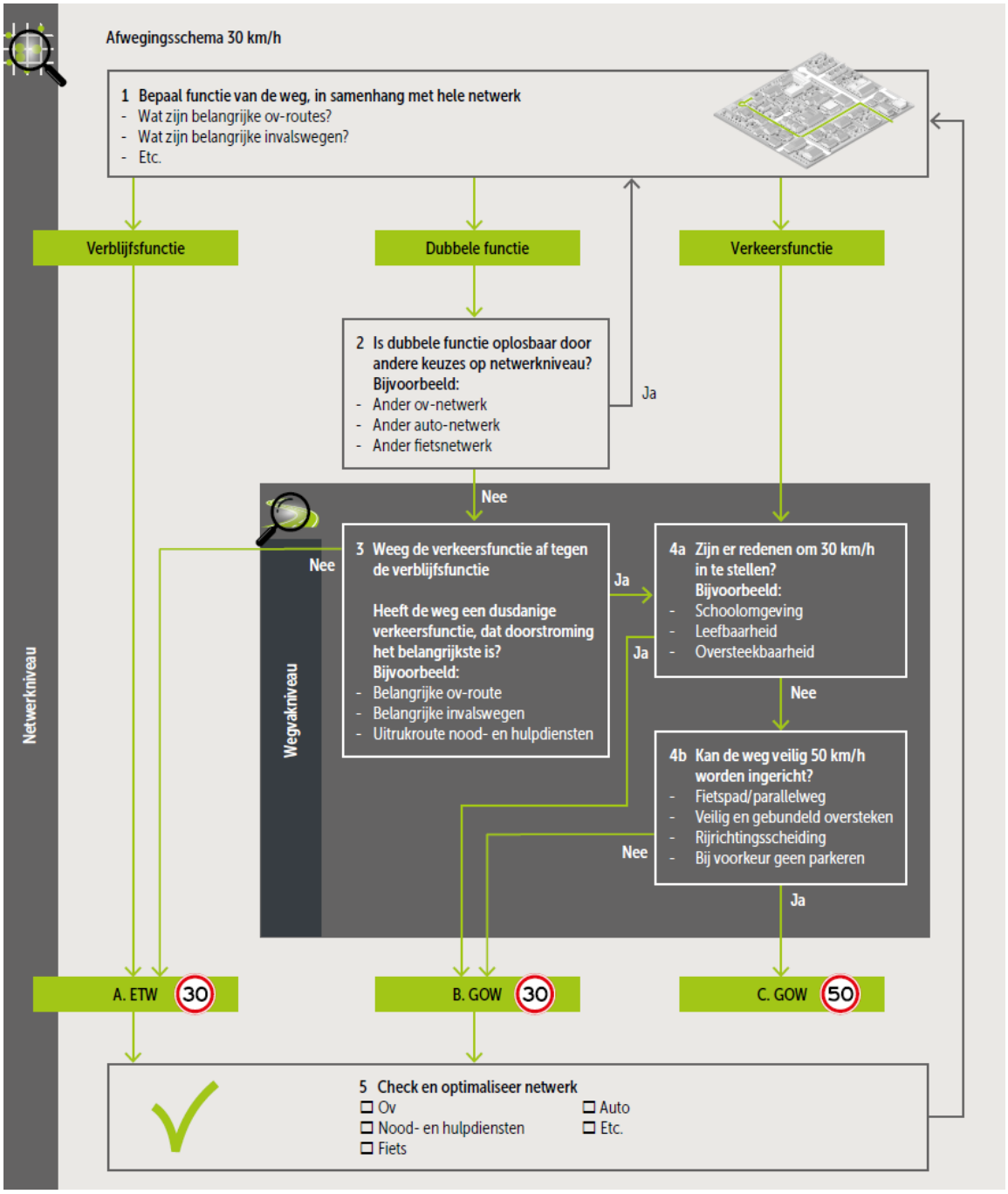

Figure 8: Consideration framework 30km/h (CROW, 2021)

13.2 APPENDIX B

All lettered basis characteristics are gathered from CROW (2012) and translated from Dutch to English.

A) Surfacing

Asphalt or clinker makes a difference to the road image of road users and their behaviour. Drivers on an asphalt road tend to drive faster and expect to be given the right of way at junctions with side roads that are paved with clinker. Unpaved paths and roads may also occur.

B) Physical lane separation

The driving direction separation is important for both recognisability and road safety. Road users pay attention to the presence of a (continuous) axis line whether they are allowed to overtake or not. The driving direction separation should be 'harder' the higher the speed limit.

C) Length marking

Longitudinal marking concerns the edge marking, cycle lane, kerb, or parking lane. From the perspective of the Essential Recognisability Characteristics, the edge marking is a distinguishing element in making the various road categories recognisable. For road users, an edge marking is useful as a guide, especially in darkness as an orientation to the side asphalt/berm.

D) Public lighting

Public lighting is useful mainly within built-up areas on all roads for social and road safety reasons. Outside built-up areas, lighting is useful at locations where there are discontinuities and at intersections. There it mainly serves road safety.

E) Agricultural traffic provision

A facility for agricultural traffic can be a parallel road next to an area access road, a passing lane or overtaking lane. If agricultural vehicles drive on roads where they can be overtaken at high speeds, there is a dangerous situation.

F) Slow traffic crossings on road sections

Pedestrians and, to a lesser extent, cyclists can cross on-road sections if the speed limit there is low; in fact, this is only the case on access roads. Outside built-up areas, traffic intensity should be low and the risk of a crash very low. Preferably, pedestrians and cyclists cross at intersections on distributor roads and flyovers on through roads.

G) Yard connection to the roadway

Plots should have a connection to the public road. From a plot, there is generally both a left turn and a right turn onto the road. About characteristic F, this is possible at low driving speeds or very low traffic intensities. Outside built-up areas, access to parcels on distributor roads and through roads is not desirable; conflicts can have serious consequences here.

H) Mixing traffic types

Mixing vehicle types on the same carriageway or, on the contrary, separating them gives roads a great distinctive character and increases the recognisability of road categories. At low speeds, all vehicle types can travel on the same carriageway. At high speeds, separation is done as much as possible because this is when the differences in mass and especially speed between them are greatest. This is safest for vulnerable road users.

I) Cycling facilities

For road users, the presence or absence of bicycle facilities is an important element in the recognition of a road type and related behaviour and expectations. Bicycle facilities are preferably separate and

peeled off to adjacent or as a bicycle lane (with bicycle symbol). Suggestion lanes are not bicycle facilities, but a visual narrowing of the lane.

K) Obstacle distance

The obstacle distance is an element that road users do not recognise as such, but which is essential for their safety. The greater the driving speeds, the greater the necessary obstacle clearance due to the speed at which the object will be hit in a collision. If the necessary obstacle distance cannot be achieved, the object should be shielded or crash-friendly.

L) Public transport stops (bus/tram)

Bus lines and tram lines preferably run along distributor roads. Stops are located in such a way that they do not pose a road safety hazard. The higher the maximum speed and traffic intensity, the more the stop should be outside the carriageway or on a separate facility (station).

M) Parking

Parking in and out poses a safety risk to other road users. Driving speeds and the degree of separation of vehicle types lead to whether parking is allowed on or next to the carriageway. If a longitudinal parking lane and a cycle lane are combined, additional measures should be implemented to protect cyclists.

N) Horizontal and vertical alignment

Arch radii and sight distances on the road largely determine driving comfort, but also driving behaviour and thus road safety. In the elaboration per road category, this basic characteristic has been translated into the design speed, because the ASVV and the Manual for Road Design base the dimensions of minimum curves and sight distances on this.

Road Image

The road image is the result of the road design that is embedded in the landscape (CROW, 2017).

Intersections

The intersection of two or more roads.

Transitions

Transition of one road category to another one.

30 km/h signs

The signage that is used to display the 30 km/h speed limit. Zone 30 signs or the normal 30 signs are possible.

Lane width

The width of the entire road where a car can drive. This means with, not separate, bicycle lanes and without pavement.

Loading and unloading

Loading and unloading by delivery vehicles.

Pavement

The paved path next to the road which is used by pedestrians.

Materials

The materials that are used in the construction of the road.

Corner radius

The radius of a corner a road makes.

13.3 APPENDIX C

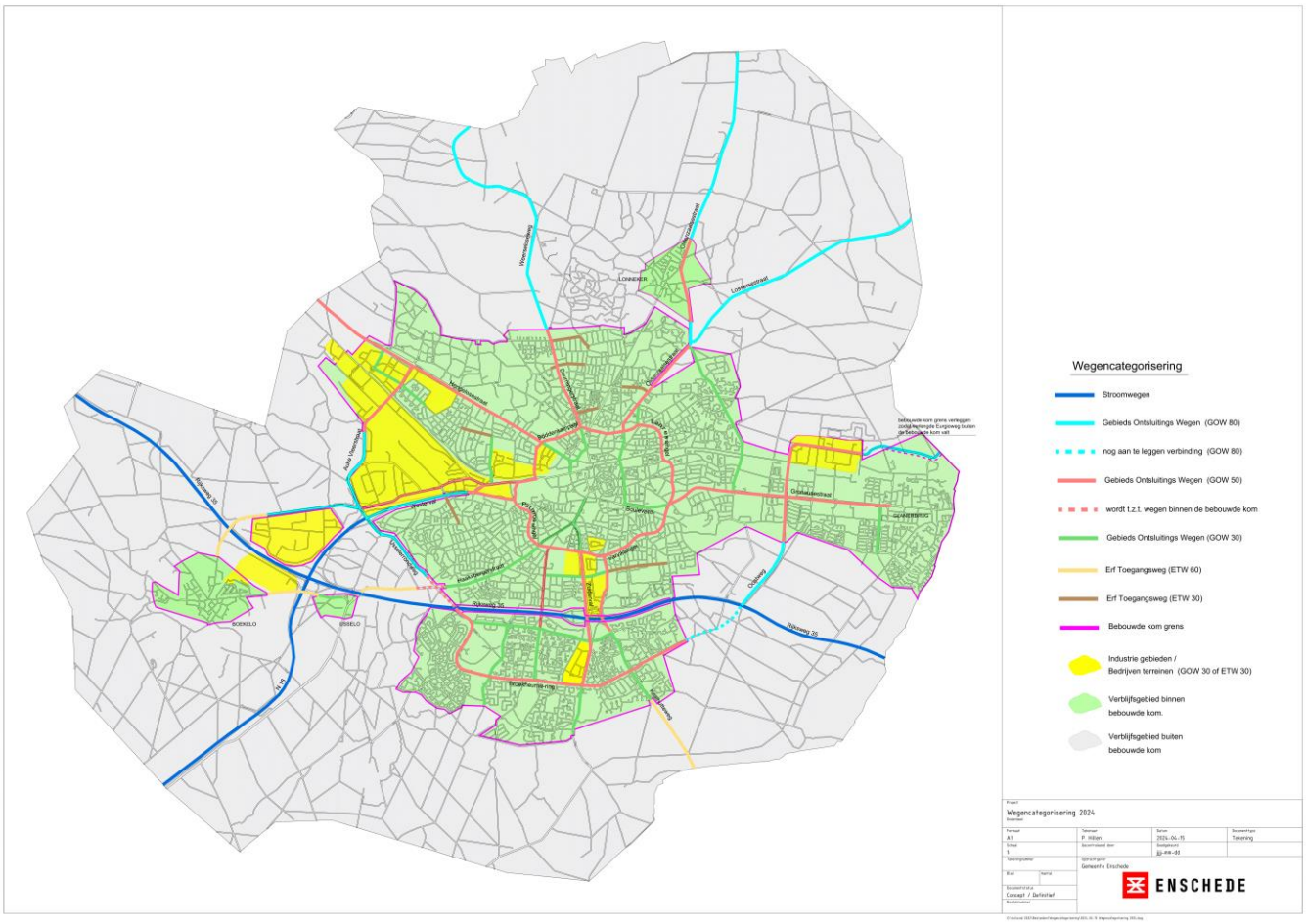

Figure 9: Existing road categorisation map made by the municipality (Hillen, 2024)

13.4 APPENDIX D

Table 3: GOW50 road characteristics and road category decision

Road	CROW analysis	Muncipal analysis	separate bicycle lane?	Safe crossing?	Driveway separation?	No parking?	No emergency services?	No public transport?	Further motivation
Noord Esmarkerrondweg (south of train tracks)	GOW30	GOW30							Dual function, not necessarily a reason for 30 km/h but layout is not safe 50 km/h. Could possibly be made so
Boulevard 1945	GOW30	GOW30					On buslane	On buslane	Dual function, but traffic flow not most important
Gronausestraat (west of Esmarkerrondweg)	GOW30	GOW50					On buslane	On buslane	Dual function, not necessarily a reason for 30 km/h but layout is not safe 50 km/h. Because of the bus lane, there is little room for this. So either remove the bus lane, or make it GOW30, where the bus lane can remain GOW50 due to the physical separation between bus and car lanes.
Heidevlinder	GOW30	GOW30					On buslane	On buslane	Dual function though traffic function is not very essential, for livability reason to make 30km/h. There is enough space to make 50 km/h safely though
Sleutelweg	ETW30	-							Residential function and soon turns into ETW30, why not immediately at the roundabout?
Oldenzaalsestraat (outside singel)	GOW30	GOW50							Dual function, road is not safely designed for 50 km/h and also has little room to do so
Oldenzaalsestraat (inside singel)	GOW30	GOW30			Partly	Partly			Dual function, road is not safely designed for 50 km/h and also has little room to do so
Potsweg	ETW30	ETW30							Dual function though traffic function is not very essential, for livability reason to make 30km/h. There is enough space to make 50 km/h safely though
Kotkampweg	ETW30	-							Residential function and soon turns into ETW30, why not immediately at the intersection?
Roomweg	ETW30	ETW30							Residential function and soon turns into ETW30, why not immediately at the intersection?
Lijsterstraat	ETW30	ETW30							Residential function
Beethovenlaan	ETW30	ETW30					Should meet requirements		Residential function and soon turns into ETW30, why not immediately at the intersection?
IJsselstraat	ETW30	ETW30							Not really a traffic function and soon turns into ETW30
Vanekerstraat/ Waalstraat	GOW30	ETW30							Dual function, does have reason for 30 km/h and layout is also not safe for 50 km/h. A traffic artery for both emergency services and public transport
Deurningerstraat (outside singel)	GOW30	GOW50							Dual function, road is not safely designed for 50 km/h and is also limited space for it, also partly a school zone
Deurningerstraat (inside singel)	GOW30	GOW30						Partly	Dual function, road is not safely designed for 50 km/h and also has little room for
Raiffeisenstraat	GOW30	GOW30							Dual function, reason for 30 km/h (liveability)
Hengelosestraat (Alleeweg - singel)	GOW30	GOW50						On buslane	Dual function, not necessarily a reason for 30 km/h but layout is not safe 50 km/h. Because of the bus lane, there is little room for this. So either remove the bus lane, or make it GOW30, where the bus lane can remain GOW50 due to the physical separation between bus and car lanes.
Hengelosestraat (inside singel)	GOW30	GOW30						On buslane	Dual function, not necessarily a reason for 30 km/h but layout is not safe 50 km/h. Because of the bus lane, there is little room for this. So either remove the bus lane, or make it GOW30, where the bus lane can remain GOW50 due to the physical separation between bus and car lanes.
De Ruyterlaan	GOW30	GOW30/-						On buslane	Dual function, reason for 30 km/h (liveability)
Jupiterstraat	GOW30	GOW30							Dual function, not necessarily reason for 30 km/h but layout is not suitable for 50 km/h
G.J. van Heekstraat	GOW30	GOW-/ETW30			Partly	Partly	Partly		Dual function, reason for 30 km/h and layout is also not suitable for 50 km/h
Rembrandtlaan	ETW-/GOW30	ETW30/-							Mainly residential function, first stretch also traffic function, but sufficient reason for 30 km/h
Parkweg (inside singel)	GOW30	-							Dual function, road is not safely designed for 50 km/h and also has little room to do so
Ripperdastraat	ETW30	-							Residential function and soon merges into ETW30
Haaksbergerstraat (singel - Zuiderval)	GOW30	GOW30	Partly						Dual function, reason for 30 km/h and layout is also not safe for 50 km/h
Haaksbergerstraat (Esso - singel)	GOW30	GOW30							Dual function, for pieces reason for 30 km/h and layout is also not safe for 50 km/h
Geessinkweg (inside ring)	GOW30	GOW30						Partly	Traffic function, reason for 30 km/h, 2 schools and lots of sports
Broekheurnerrondweg (east of Geessinkweg)	GOW30	GOW30	Partly		Partly			Partly	Traffic function, not necessarily reason for 30 km/h but layout is not safe for 50 km/h, is possible with major modifications
Burgemeester M. van Veenlaan	GOW30	GOW50							Traffic function, not necessarily reason for 30 km/h but layout is not safe for 50 km/h, up to Wethouder Beversstraat possibly room for 50, after that not really
Buurserstraat (outside ring)	GOW30	GOW30				Partly			Dual function, reason for 30 km/h (liveability)
Vlierstraat (west of Buurserstraat)	GOW30	GOW30							Dual function, reason for 30 km/h (liveability)
Knalhutteweg	GOW30/50	GOW30/50						Partly	Traffic function, partly reason for 30 km/h (school zone) layout is safe for 50 km/h though
Kuipersdijk (inside singel)	GOW30	-							Dual function, reason for 30 km/h (liveability)
Wethouder Beversstraat	GOW30/50	GOW30	Partly						Traffic function, reason for 30 km/h (school zone) and there is room for a safe 50 km/h layout though
J.J. van Deinselaan (east of Doctor Wagenaarstraat)	GOW30	ETW30				Partly			Dual function, reason for 30 km/h (liveability)
J.J. van Deinselaan (west of Doctor Wagenaarstraat)	ETW30	ETW30							Dual function, but traffic flow not most important
Goolkatenweg	ETW30	-							Residential function, soon merges into ETW30
Richtersweg	ETW30	-							Residential function, soon merges into ETW30
Broekheurnerweg	GOW30	-							Dual function, reason for 30 km/h for liveability and there is no room for 50 km/h
C.F. Klaarstraat	ETW30	-							Residential function

13.5 APPENDIX E

- **Enforcement**

The interview with the police was for both the enforceability of the speed limit and the police as an emergency service. The police are willing to enforce the 30 km/h speed limit for GOW30 roads when they are designed to conform to the CROW guidelines. For the police as an emergency service, they stated they did not have specific requirements and that ambulance and fire brigades would have more requirements for the road design. They did state that using chicanes as horizontal alignment should be avoided since they often lead to an increase in speed. Instead, narrowing along the full width of the road should be used. For transitions, using exit structures more frequently could help to decrease speed. However, using the CROW guideline for transitions as a basis is fine. For signage of the road, there is a clear preference for using the Zone 30 signs instead of the normal 30 signs. This is because you would need to put normal 30 signs at every intersection, which would lead to an enormous number of signs in the city. The Zone 30 signs only need to be put at the transitions. Finally, the road image should fit with the speed limit. This means putting greenery close to the road and creating a varying road view.

- **City engineers**

The city engineers made clear that material transitions should be avoided as much as possible. Different coated asphalt or adding a print to it is possible. In terms of durability, baked clinkers are a good option. The construction underneath the road is a point of attention. The ETW30 constructions for these clinker roads are not made for the intensity of motorized vehicle volumes of GOW30 roads. Another point raised is sustainability, to make the road as sustainable as possible, standard materials and elements should be used. For the other design characteristics, they did not foresee any problems in following the CROW guidelines. They agreed with not having lane separation since this will help decrease track formation on the road surface. They stated keeping lane separation to a minimum would help in maintaining the road. Finally, they stated that for parking, half-open surfacing could be used to differentiate parking spots from the road and pavement.

- **Public lighting**

For public lighting, the TOR of Enschede must be followed. Depending on the road width, the distances between light poles will be calculated by the team. However, this is only an approximation and when designing roads, the precise placement of light poles always needs to go via the public lighting team. For the narrow road, the standard 4-meter light poles can be placed on alternating sides, as is the case for ETW30. For the wide road version, the 6-meter light poles must be placed on one side. Using the 4-meter light poles would mean that the distance between the poles would become too low and would lead to an increase in costs. For separate bicycle lanes, it could be possible that separate light poles for the bike path are necessary if the distance from the main road is too large. The team did not have any opinion about other design characteristics.

- **Landscapers**

The goal of this team is to get as much greenery as possible in the landscape of the roads. Preferably close to the road since this will lead to a decrease in travel speed. There is no one vision for how to put this greenery in the landscape, as there is a different vision for each road or area in the city. This cannot be standardized. The obstructing factor when putting in greenery is a lack of space, parking on the same level as the pavement is a way to save space to put in more greenery. What also helps in creating a credible speed limit is the material and width of the road. For that, the CROW guidelines should be followed as much as possible.

- **Maintenance**

The maintenance team also pointed out the construction under the road as a potential problem. Next to that, they also pointed out that parking at the same level as the pavement could lead to more illegal parking on the pavement. For this, they stated it was important to clearly distinguish the parking spots from the pavement. They proposed using the half-open surfacing option of grass concrete tiles. For the surfacing of the road itself, they did not see any problems other than noise regulations. Based on their advice, a meeting was planned with the team working on these regulations for the municipality. The maintenance team liked the idea of plateaus on intersections. For horizontal alignment, they stated that chicanes have led to a speed increase instead of a decrease. They would like as few obstacles as possible near roads, this also includes street signs. For greenery, they called on common sense when designing it. Designers need to think about how it needs to be maintained. Putting for example a hedge next to the road means maintaining it will lead to major disruption for the traffic on the road. Also, large plots for greenery are easier to maintain than many small ones. They did advocate for robust greenery, meaning small, medium, and large greenery in the road view. This will help with biodiversity and liveability in the area.

- **Road managers**

The forgiving kerbstones alongside the roads are helpful for road safety and are already often used in other municipalities. Whereas, in Enschede, it is currently not used often. Once again, the construction underneath the road was pointed out as a potential problem. The importance of enforceability was also pressed. For horizontal alignment, narrowing across the full width of the road is preferred. Finally, using standard materials and elements is important.

- **Emergency services**

Using the CROW guidelines will fit most demands of the emergency services. However, there are some additions and alterations. The first is in the surfacing, for patient comfort reasoning in the ambulance, asphalt would be required. Not having any physical lane separation is helpful when passing through traffic. The forgiving kerbstones also make it easier for normal traffic to get out of the way. They want to see 8cm bus-friendly plateaus and speed bumps for vertical alignment. The corner radius of GOW50 roads is preferred. For lane width, they referenced their handbook for reachability (Brandweer Nederland, 2020).

- **Environmental specialist**

While noise regulations do not impact the standard design, it is important to clarify that changes in the road need to comply with these regulations. This is determined by this team and based on their findings, changes can be made to the design. For example, in surfacing, silent clickers can be put into place. Or the location and height of vertical alignment can be changed. However, this is on a case-by-case basis.

- **Public transport services**

The public transport operator of Enschede, Arriva, agreed for the most part with the combination of the CROW guidelines for GOW30 and those for public transport (CROW, 2020). For surfacing, they had the same preference as the emergency services. Not just for comfort reasons, but modern electric city buses are heavy, and asphalt is much more durable than clinkers. Asphalt also produces less noise and vibrations when a bus drives over it. For stops, having them on the road is not a problem. However, if there is not enough space to redirect the bicycle lane around the bus stop, the bicycle lane should be legally interrupted where the stop is. Otherwise, buses cannot legally stop at the bus stop. For vertical alignment, buses would like as few speed bumps as possible, but putting at least 7-meter-long plateaus with the correct bus-friendly on and off ramps on intersections is acceptable. For additional vertical alignment, bus-friendly Gumacon speed bumps should be used. For all vertical alignment

measures, a bus should be able to go over it fully straight. This means speed bumps should not be placed in turns. For the plateaus, if a bus needs to turn, the plateau should continue for 7 meters starting from the road axis. The road width should be in line with the CROW guidelines, which means at least 6.5 meters (CROW, 2020). Finally, the corner radius should conform to the TOR, which means 12 meters (Gemeente Enschede, 2024).

- **Traffic engineers**

The final stakeholder is the traffic engineering team of the municipality. This was mainly the supervisor from the municipality for this thesis. No structured interview was performed, but feedback was given during weekly meetings. The input for the design framework given was the following. For surfacing, the main bicycle routes of Enschede must have asphalt for the bicycle lanes. These are the "doorfietsroutes" or regional cycle routes as determined by the Fietsvisie Enschede 2030 (Groenewolt & Lems, 2021). When the main surface of the road is asphalt, there should be length markings on the road to give the impression of a narrower runner.

13.6 APPENDIX F

Table 4: Overview of stakeholder input for design characteristics

	CROW	TOR	Enforcement	City engineers	Public lighting	Landscapers	Maintenance	Road managers	Emergency services	noise	Public transport services	Traffic engineers
A. Surfacing	x	x		x			x		x	x	x	x
B. Physical lane separation	x			x					x			
C. Length marking	x			x				x	x			x
D. Public lighting	x	x			x							
E. Agricultural traffic provision	x											
F. Slow traffic crossings on road sections	x											
G. Yard connection to the roadway	x											
H. Mixing traffic types	x											
I. Cycling facilities	x	x										
K. Obstacle distance	x	x					x					
L. Public transport stops (bus/tram)	x	x									x	
M. Parking	x	x		x		x	x					
N. Horizontal and vertical alignment	x	x	x				x	x	x	x	x	
Road image	x		x			x	x					
Intersections	x						x				x	
Transitions	x		x									
30 km/h signs	x		x				x					
Lane width	x	x				x			x		x	
Loading and unloading	x											
Pavement		x										
Materials		x		x				x				
Corner radius		x							x		x	

13.7 APPENDIX G

A. Surfacing

For surfacing, the CROW guideline is taken as a basis. This means that the TOR must be changed to facilitate the new surfacing for GOW30 roads. The choice of baked clinkers follows the preference of the city engineers for a sustainable material. Because the maintenance and noise team were concerned about noise production by changing the surfacing, a paragraph discussing the noise regulations and their impact on the surfacing has been added. In some instances, it might lead to silent clinkers being used instead of baked clinkers. Following the input of the emergency and public transport services, an option has been added for asphalt on GOW30 roads. Finally, the traffic engineers stated that some bicycle routes should have a surface of asphalt, which is also included in the framework. They also stated that in some cases, it would not, politically, or financially, be possible to replace asphalt with open pavement. For this, a paragraph has also been added at the end of the framework.

B. Physical lane separation

Take directly from the CROW design characteristics for GOW30. With added support from the city engineering team because of the decrease in track formation. The emergency services also saw the lack of physical lane separation as a positive.

C. Length marking

The CROW guideline is followed for this design characteristic but specified for multiple stakeholders. The city engineers clarified that material transitions should be decreased. Which is why strips with a different material are not favoured. Instead, a different coated or printed asphalt is given as a design characteristic. The forgiving kerbstones are also supported by road managers because they improve road safety. Emergency services also favour them because they offer cars more options to get out of the way in case of an emergency. The length markings in the form of different coated or printed asphalt are also supported by the traffic engineering team because they create the impression of a narrower runner.

D. Public lighting

For public lighting, the placement and choice of pole directly follows the TOR and the public lighting team of the municipality. Where the CROW prefers 4-meter poles everywhere, this is not a good option in the case of the wide profile according to the public lighting team.

E. Agricultural traffic provision

Taken directly from the CROW design characteristics for GOW30.

F. Slow traffic crossings on road sections

Taken from the CROW design characteristics for GOW30. Added that the crossings should be on intersections where plateaus are used. The attention-raising measures should be in line with characteristic N about the alignment.

G. Yard connection to the roadway

Taken directly from the CROW design characteristics for GOW30.

H. Mixing traffic types

Taken directly from the CROW design characteristics for GOW30.

I. Cycling facilities

Following the CROW design characteristics for GOW30, there is an option for GOW30 roads with and without separate bicycle lanes. While having bicycle lanes present on the road helps

with the credibility of the speed limit, separate lanes are safer for bicycles (CROW, 2023). In cases where there currently already is a separate bicycle lane, it does not make sense to remove them when transforming the road to GOW30. The dimensions of the cycling facilities conform to both the TOR and the CROW guidelines.

K. Obstacle distance

CROW states that the standard for ETW30 should be followed. This is stated in the TOR. Added is the minimization of obstacles near roads, as stated by the maintenance team.

L. Public transport stops (bus/tram)

Following the CROW guideline, buses will halt on the road. These stops need to conform to the TOR, where preferably, the bicycle path is redirected around the stop. If that is not possible, the bicycle path should be interrupted, as the public transport services clearly stated. A not physical local overtaking ban will be put in place following the CROW guideline, this ensures that emergency services will still be able to overtake at these bus stops.

M. Parking

Following the CROW guideline results in 2 options for parking. One with and one without separate bicycle lanes. The dimensions of these parking spots should conform to the TOR. Parking on the same level as the pavement comes from the landscapers and the other teams did not have problems with this. Maintenance and city engineers emphasise the importance of choosing a material that differentiates the parking spots from the pavement. For this, half-open surfacing in the form of grass concrete tiles will be used.

N. Horizontal and vertical alignment

Following the CROW guideline, the basis for alignment is the same as for ETW30. This means that the TOR should be followed for designing the alignment elements. Plateaus will be put on intersections, if the spacing between the intersections is too long, additional alignment will be placed following the TOR. Buses and emergency services have the same requirements when it comes to alignment. The bus-friendly version of plateaus and speed bumps should be used on these routes. Chicanes as horizontal alignment should be avoided as stated by the enforcement and maintenance teams. Instead, full-width narrowing is preferred following the road managers. Finally, concerning noise production, a paragraph is added underlining the possible effects alignment might have on the noise a road produces.

Road image

Follows the CROW design characteristics for GOW30, with added importance highlighted by the enforcement. The input from the landscapers is combined with the maintenance requirements for the maintenance team. This is why big patches of varied robust greenery are the basic premise.

Intersections

Taken from the CROW design characteristics for GOW30. Additionally, a preference is given for plateaus because they provide a varied road view and are a speed-reduction method. This is also preferred by the public transport services and maintenance team.

Transitions

Taken directly from the CROW design characteristics for GOW30. Enforcement did state a preference for exit structures but did see the guideline as a good basis.

30 km/h signs

The CROW guideline gives two options for 30 km/h signs. One is using the “zone 30” sign, the other is using the normal 30 km/h sign. These normal signs should then be placed at every intersection, therefore the “zone 30” sign option is chosen. The maintenance team clearly stated they want as few obstacles as possible next to the road and the enforcement clearly stated their preference for fewer signs.

Lane width

Take from the CROW design characteristics for GOW30. This is also in line with the wishes of the emergency and public transport services. The minimum bicycle suggestion lane width is taken from the TOR.

Loading and unloading

Taken directly from the CROW design characteristics for GOW30. Where there is also a difference depending on if there is a separate bicycle lane available (option b)) or not (option a)).

Pavement

Taken directly from the TOR of Enschede.

Materials

Given the input from the city engineers and road managers to use standardized materials and elements. The TOR is followed concerning materials and elements. Although the current TOR is not fully applicable to this GOW30 guidelines. For example, the TOR currently states that GOW roads should be of asphalt or concrete, that is not the case for GOW30.

Corner radius

The existing corner radii are taken from the TOR for GOW50 roads. Emergency and public transport services require these radii to comfortably make the corners. This is also not difficult to adhere to since current GOW50 roads already comply with these and GOW30 roads will mostly be on these existing road paths for GOW50.

13.8 Appendix H

Table 5: Preferred intersection forms for GOW30 roads (CROW, 2023). The original table offers more information.

INTERSECTION GOW30 WITH	INTERSECTION FORM
YARD	Exit
ETW30	Preferably exit or priority intersection. (with priority for GOW30) or possibly an intersection with a traffic control installation
GOW30	Preferably roundabout; possibly priority intersection or an intersection with a traffic control installation
GOW50	Preferably roundabout; possibly priority intersection (with priority for GOW50) or an intersection with a traffic control installation
PUBLIC TRANSPORT LANE	Priority intersection or an intersection with a traffic control installation
BICYCLE STREET	Priority intersection, or an intersection with a traffic control installation or (bicycle) roundabout
SOLITARY BIKE PATH	Priority intersection, or an intersection with a traffic control installation or (cycle) roundabout

13.9 Appendix I

Table 6: Basic characteristics for transitions of GOW30 roads (CROW, 2023). The original table offers more information.

TRANSITION FROM	TRANSITION FORM
YARD TO GOW30	Exit construction with end of yard sign and with sign 30
GOW30 TO YARD	Entrance construction with yard sign
ETW30 TO GOW30	Gate construction
GOW30 TO ETW30	Gate construction
GOW50 TO GOW30	Gate construction, with speed reduction measure, with sign 30
GOW30 TO GOW50	Sign end 30
ETW60 TO GOW30	city limit, with speed reduction measure, with sign 30
GOW30 TO ETW60	town limit, end of city limit sign, with sign 60

13.10 APPENDIX J

The design framework for GOW30 in Enschede is shown below. It consists of two parts. The first is the decision tree in Figure 10. The second is the list with all road characteristics and their different options. The way of working is having both parts next to each other and starting by following the decision tree. Making the decisions results in which option of the design characteristic should be used for the specific road. If the decision tree is followed completely, all design characteristics with multiple options are specified. Going through the entire list of road characteristics will then result in a list of characteristics a specific road should have. These characteristics are a guideline, and deviations are possible.

After the road characteristics list, some additional notes to keep in mind when following the design framework are presented. Finally, there are some atmospheric impressions of what several types of GOW30 roads could look like.

Figure 10: Revised decision tree for basic design features of GOW30 roads.

A. Surfacing

a) Apply open pavement over the entire cross-section in the form of baked clinkers. Except when the road is on a “doorfietsroute” or regional cycle route. These routes are determined in the Fietsvisie Enschede 2030 (Groenewolt & Lems, 2021) and should have asphalt bicycle lanes.
b) The main surface of the road will be asphalt. Preferably using a different colour or texture than the standard asphalt used on GOW50 roads.
c) Apply open pavement over the entire cross-section in the form of baked clinkers.

B. Physical lane separation

No physical lane separation (CROW, 2023).

C. Length marking

a) Only apply length marking for bicycle lanes. Apply forgiving kerbstones alongside bicycle lanes.
b) Apply length marking for bicycle lanes. Apply forgiving kerbstones alongside bicycle lanes. Use different coated/coloured asphalt for a narrow central strip. This will create two narrow track runners. This central strip can also be made by applying a clinker print on the asphalt.
c) No length marking. Applying forgiving kerbstones alongside lanes is not strictly necessary.
d) Applying forgiving kerbstones alongside lanes is not strictly necessary. Use different coated/coloured asphalt for narrow central and side strips. This will create two narrow track runners. These strips can also be made by applying a clinker print on the asphalt.

D. Public lighting

a) 4-meter light poles, currently used for ETW30. Placed on alternating sides alongside the road. Placement conforms to TOR Chapter 5 (Gemeente Enschede, 2024). Distance between poles depends on road width, as seen below in Table 1.

Table 7: Distance between poles for low-intensity GOW30 roads

Road width	Average distance between poles
5.9m	36m
6.4m	35m
6.9m	34.5m
7.4m	33.5m
7.9m	32.5m
8.4m	31m

b) 6-meter light poles, currently used for GOW50. Placed on one side of the road, with, on average, 40 meters separating the poles.
c) 4-meter light poles, currently used for ETW30. Placed on alternating sides alongside the road. Separate lighting on the separate bicycle lanes might be necessary if the light is obstructed or the distance to the road itself is too far. Placement conforms to TOR Chapter 5 (Gemeente Enschede, 2024). Distance between poles depends on road width, as seen below in Table 2.

Table 8: Distance between poles for GOW30 roads with separate bicycle lanes

Road width	Average distance between poles
5.8m	36m
6.5m	35m

E. Agricultural traffic provision

No special provisions for agricultural traffic (CROW, 2023).

F. Slow traffic crossings on road sections

Bundled and safe crossing on plateaus when possible. If it is not possible to put the crossing on an intersection, include attention-raising measures using colour and/or vertical alignment. Conform to point N.

G. Yard connection to the roadway

Yard connection to the roadway is allowed (CROW, 2023).

H. Mixing traffic types

Motorised, agricultural and motorbike traffic is allowed on the roadway. Bicycles and moped riders ride on bicycle lanes or separate bike paths. Pavement is present for pedestrians (CROW, 2023).

I. Cycling facilities

a) Bicycle lanes are present on the road. Minimal width of 1.75 m, ideal width of 2.2 m, in red colour (Gemeente Enschede, 2024; CROW, 2023).
b) Separate bicycle paths are present. The minimal width is 2.5 meters for a 1-way path and 3.5 meters for a 2-way path. The surface should be red (Gemeente Enschede, 2024).

K. Obstacle distance

Use standard for ETW30 roads as determined in the TOR (Gemeente Enschede, 2024). Minimize the number of obstacles near roads.

L. Public transport stops (bus/tram)

a) Not present.
b) Halt on the road. If present, the bicycle lane should be redirected around the stop, conform detail 32 of the TOR (Daniels, 2023). If that is not possible. Use detail 31 of the TOR (Daniels, 2023), make sure to interrupt the bicycle lane. Apply a local overtaking ban using signs and a continuous line in the middle of the road.

M. Parking

a) Preferably not present, but longitudinal parking is safely possible when extra scare and exit lane between the bicycle lane and parking box. This extra lane should be 50 cm wide (CROW-Fietsberaad, 2016). The parking spots will be located on the same elevation as the pavement using the forgiving kerbstones. The material will be semi-open hardening like grass concrete tiles to differentiate it from the pavement. The dimensions of the parking spots conform to the TOR Chapter 4 (Gemeente Enschede, 2024).
b) Preferably not present, but longitudinal parking is safely possible. The parking spots will be elevated using the forgiving kerbstones. The material will be semi-open hardening like grass concrete tiles to differentiate it from the pavement. The dimensions of the parking spots conform to the TOR Chapter 4 (Gemeente Enschede, 2024).

N. Horizontal and vertical alignment

a) Alignment uses the same standards as ETW30. Vertical alignment on intersections in the form of 12 cm plateaus with a different colour. Prefab concrete elements are used as ramps. For the start of the plateau, the 12 cm 30km ZONE on detail 24 of the standard details of the TOR (Daniels, 2023) is used. The minimum length of the plateau is 3 meters. In long stretches without side connections, speed reduction measures need to be present with a minimal spacing of 70 and a maximal spacing of 100 meters (Gemeente Enschede, 2024). These can be in the form of the plateaus as described above, however, if there is no space for a plateau, a speed bump can be put into place. For this, the 8cm 30km ZONE speed bump on detail 23 of the TOR (Daniels, 2023) is used. Using horizontal alignment should be avoided.

b) Alignment uses the same standards as ETW30. Vertical alignment on intersections in the form of 8 cm plateaus with a different colour. Prefab concrete elements are used as ramps, which are 2.40m long. For the start of the plateau, the bus-friendly 8 cm 30km ZONE on detail 23 of the standard details of the TOR (Daniels, 2023) is used. The minimum length of the plateau is 7 meters (CROW, 2007). The plateau should also continue 7 meters from the road axis to the intersecting road if a bus needs to make that turn. In long stretches without side connections, speed reduction measures need to be present with a minimal spacing of 70 and a maximal spacing of 100 meters (Gemeente Enschede, 2024). These can be in the form of plateaus, however, if there is no space for plateaus, a speed bump can be put into place. For this, the standard Gumacon bus-friendly speed bump is used. These need to be put on straight parts of the road. Using horizontal alignment should be avoided.

Road image

Create a varied road view. This is done in the primary view by changing the roadway itself. Physically using horizontal and vertical alignment and visually using colours and patterns. In the environment surrounding the road, the secondary view, this is done by bringing varied robust greenery close to the road and making sure there is no pattern in the street view. With creating greenery, keep maintenance in mind. Refrain from using a lot of small patches of greenery. Big patches of greenery are easier to maintain. Greenery located adjacent to the road should be maintainable without obstructing the road. This means placing a hedge right next to the road should be avoided.

Intersections

For intersections, the preferred intersection forms for GOW30 roads from CROW (2023) are used. These can be seen in Appendix . To create a varied road view, plateaus are preferred. Especially for public transport routes.

Transitions

For transitions to different road categories, the basic characteristics for transitions between road categories on road sections from CROW (2023) are used. These can be seen in Appendix .

30 km/h signs

When entering a GOW30 road, the maximum speed of 30 km/h is indicated by a begin zone 30 sign. Leaving a GOW30 road is indicated with an end zone 30 sign. Except when going from a GOW30 to an ETW30 road, since the 30 zone continues. The current signage of ETW30 remains the same.

Lane width

a) The small profile for roads with bicycle lanes made by CROW-Fietsberaad (2016) is used as a base. The profile has the width of the bicycle lanes between 1.75 and 2.2 meters. The centre runner is between 2.2 and 3.8 meters. Then between the centre runner and the bicycle lanes, there is 10 cm for lining. The total width of the road will then be between 5.9 and 8.4 meters. 6.5 meters is the minimum road width for public transport purposes, which is the same as for ETW30 (CROW, 2020).
b) If it is possible, create separate bicycle lanes with lane width option c). Otherwise, the wide profile for roads with bicycle lanes made by CROW-Fietsberaad (2016) is used as a base. The profile has the width of the bicycle lanes between 1.75 and 2.25 meters. The centre runner is between 4.8 and 6 meters. Then between the centre runner and the bicycle lanes, there is 10 cm for lining. The total width of the road will then be between 8.5 and 10.7 meters.

c) The minimal width is 5.8 meters for the whole road. 6.5 meters is the minimum lane width for public transport purposes, which is the same as for ETW30 (CROW, 2020).

Loading and unloading

a) Loading and unloading outside car lanes and bicycle lanes (CROW, 2023).
b) Loading and unloading outside car lanes and bicycle lanes. If this is not possible, it could be done on the roadway (CROW, 2023).

Pavement

Pavement alongside the road is present. At least 1.2 meters, for short narrowing, i.e. light poles, 0.9 meters is acceptable (Gemeente Enschede, 2024).

Materials

Use materials and elements that are standard for the municipality and used more often.

Corner radius

a) Optimally 10 meters (Gemeente Enschede, 2024).
b) Optimally 12 meters (Gemeente Enschede, 2024).

Surfacing options a and c use open pavement over the entire cross-section. If this is not realizable, an alternative with asphalt could be made. This alternative will take length marking option b, option c should be taken if there is a separate bicycle lane. An example of this is illustrated in the CROW guidelines (CROW, 2023).

For public lighting, the placement of the light poles should always be checked and is dependent on the surroundings of the road. The given light pole distance is only an average when you do not have to consider the surroundings.

Another important aspect is noise. Changing the road network by decreasing the maximum speed, applying open pavement, and adding vertical alignment influences the noise produced by vehicles on the road. How much noise a road is allowed to produce is determined by the “omgevingswet”. All roads should be compliant with this law. To ease this process, a traffic environment map is in development for the municipality of Enschede. The proposed design should be put into this map, which will show if the proposed design fits within the noise limits. The two most important aspects of the road will be A surfacing and N alignment. For A, instead of baked clinkers, silent clinkers can be used to decrease noise. For N, locations of vertical alignment can be changed or instead of a 12 cm version, the lower 8 cm version can be used. However, since this traffic environment map is still in development, the effects of these changes cannot be guaranteed.

For emergency services and their requirements for the network. The handbook for firewater supply and accessibility (Brandweer Nederland, 2020) can be used.

Following this design framework leads to a basis for the road design. Below are three examples of what different GOW30 roads could look like. The letters in the figures correspond to a basic design feature. Figure 11 shows a GOW30 road which is not an emergency or public transport route, without separate bicycle lanes and with a desired intensity lower than 6,000 motor vehicles per 24h. Going through the decision tree for this road results in design characteristics that can be seen in the figure. The road has an open pavement across the entire cross-section, forgiving kerbstones alongside the bicycle lanes. 4-meter light poles alternating from side to side can also be seen, with varied greenery

in big green spaces in between the light poles. Longitudinal parking on grass concrete tiles is present on the same elevation as the pavement. Finally, the total lane width is 6 meters.

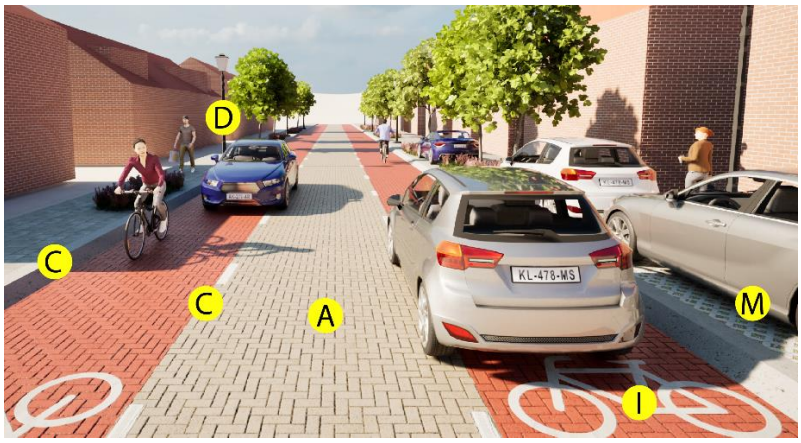

Figure 11: Atmosphere impression for a narrow GOW30 road.

Figure 12 shows a GOW30 road which is a public transport route without separate bicycle lanes. The road has a desired intensity higher than 6,000 motor vehicles per 24h and is a high-intensity bus route. It is not possible to create separate bicycle lanes which means the wide lane width option is picked.

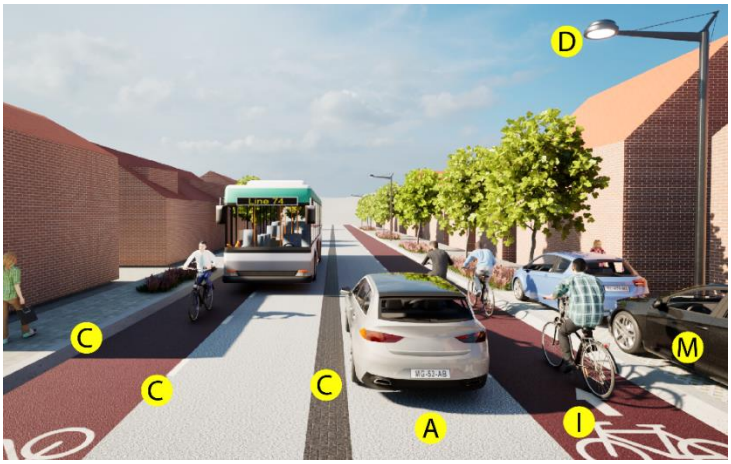

Figure 12: Atmosphere impression for a wide GOW30 road.

Figure 13 shows a GOW30 road which is not an emergency or public transport route but does have separate bicycle lanes.

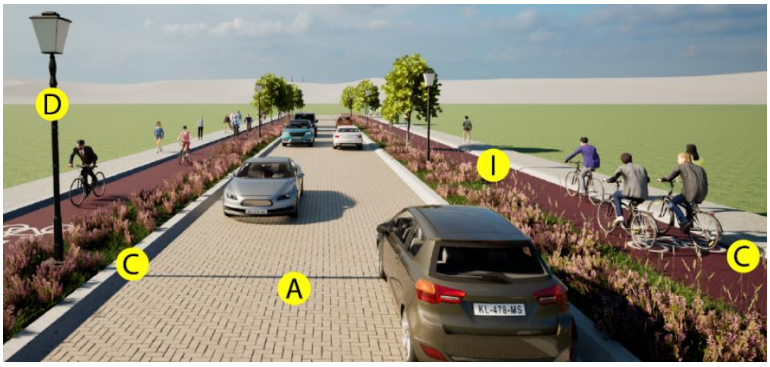

Figure 13: Atmosphere impression for a GOW30 road with separate bicycle lanes.