Institute of Transport Economics
Norwegian Centre for Transport Research

ENGLISH Summary

# Squeezing safety margins

## How does the design of roads affect road safety and how do societal changes affect the design of roads?

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This report deals with three main topics. (1) What is known about the safety impacts of various design elements of roads, in particular cross section and alignment? Are there interactions between the design elements with respect to their effects on safety? (2) How may future societal developments influence the design standards for roads? (3) Can the road sector learn anything from aviation sector and rail sector concerning how to increase safety? It is concluded that current knowledge regarding design elements of roads is highly uncertain. The results of empirical studies are not always consistent, and there are very limited studies of interactions between design elements. The implications of future societal developments for the design of roads are difficult to predict. The aviation and rail sectors have attained very high safety. The road sector may try to introduce some of the elements that may have contributed to the safety of aviation and rail.

## Elements of road design and equipment

The first topic addressed in this report is to summarise current knowledge about the impacts on safety of design elements of roads and potential interactions between design elements. As far as the relationship between each design element and traffic control device and road safety is concerned, the main points of current knowledge can be summarised as follows:

- Wider lanes tend to improve safety, but the relationship may vary according to the type of road.
- Wider shoulders are associated with fewer accidents.
- Horizontal alignment (e. g. curve radius, curve length) has a complex relationship to safety which is influenced by many interactions.
- Vertical grades and crest and sag curves are associated with an increased number of accidents.
- Road lighting reduces the number of accidents.
- Median guard rails reduce the number of accidents, in particular the most severe accidents.
- Guardrails along the edge of the road, as well as clear safety zones, reduce both the number and severity of accidents.

- Speed limits are important for safety by influencing speed, which is a major risk factor for accidents and injuries.
- The quality of the road surface (e. g. evenness, rut depth, friction) has a major influence on road safety.
- Rumble strips are associated with fewer accidents.
- Directional markings and retroreflective delineator posts improve safety in horizontal curves.
- Speed enforcement reduces the number of accidents.

## Interactions between design elements

Less is known about interactions between design element and road safety than about the relationship between each design element and road safety. The main points of current knowledge can be summarised as follows:

- Increasing lane width combined with reduced shoulder width increases the number of accidents. If both lane width and shoulder width are reduced, there will also be an increase in the number of accidents.
- Shoulder width has a larger effect on accidents in curves than on straight sections. The effect of a combined reduction of horizontal curve radius and shoulder width are likely to be greater than the sum of their separate effects.
- Reducing both lane width and horizontal curve radius may have a greater effect than changing just one of these elements.
- Reduced road maintenance may have a greater effect if design standards are also reduced than if they are unchanged.
- Shoulder rumble strips may offset (partly or completely) the detrimental effects of narrower shoulders.
- Centreline or shoulder rumble strips may (partly or completely) offset the detrimental effects of narrower lanes.
- A combination of horizontal and vertical curves increases the number of accidents more than isolated changes in horizontal or vertical curves.
- Sharper curves combined with a smaller safety zone may have a greater effect on accidents than the sum of separate changes of each element.
- A combined reduction of alignment standards and winter maintenance may have a greater effect than the sum of the separate changes.

These are the cases where interactions have been found or are likely to occur. In many cases, knowledge is lacking or inconclusive.

## Societal changes and road design

The second main topic addressed in this report concerns the implications of societal changes for the design of roads. The main findings can be summarised as follows:

- More advanced driver support systems and increasingly automated driving may to some extent offset the impact of poor road design.
- An increasing share of motorcycles and heavy vehicles will increase the importance of safety margins.
- The number of older drivers will increase, but their accident rate may increase less than it did in the past.
- Lower safety margins, for example smaller safety zones, reduced road lighting or road maintenance can affect older drivers more than other age groups.

- Climate change may increase the wear and tear of road surfaces and necessitate a higher standard for drainage and renewal of road surfaces.

## Lessons from aviation and rail

Aviation and rail are very safe modes of transport. The third topic addressed in the study is what the road sector can learn from these modes of transport in order to make travel by road safer than it is today. This topic was investigated in focus groups with persons with detailed knowledge of the safety of aviation and rail, interviews and document studies. The main findings can be summarised as follows:

- Aviation and rail are both characterised by a more highly developed safety culture than the road sector. Highway agencies can promote the development of safety culture in professional road transport by making it a requirement when entering contracts with e. g. construction companies or transport companies.
  There is extensive event reporting in both aviation and rail. A similar system does not exist in the road sector, but the regional traffic management centres receive many unsolicited reports from road users. A more systematic use of these reports could identify risk factors that may be brought under better control before they lead to accidents.
  Aviation and rail practice very frequent inspections of infrastructure. The road sector might want to consider a programme of inspecting roads and their equipment more frequently in order to prevent defects from developing or repair them more quickly than today.