

Workshop: Design for Safer Cycling

Tu4/C1: Impacts on Safety and Feeling of Safety of Cycling Infrastructure in Copenhagen

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Introduction

Cycling is a significant mode of transport in Copenhagen, e.g. 36 % of all trips to and from workplaces in Copenhagen are done by bike. 40 km of new cycle tracks have been constructed over the last 10 years, and the total network now amounts to some 340 km. The cycle tracks are necessary if Copenhageners are to dare to cycle. The large numbers of cycle tracks have made cyclists feel safer on their bikes, and the cyclists have responded positively to the promotion. In the last 10 years bicycle traffic has grown by 41%.



Scene from Nørrebrogade in Copenhagen with 30.000 cyclists a day on cycle tracks

Cycle tracks in Copenhagen are situated in both sides of the main streets. They are one-way, often 2.2 - 2.5 m wide. The cycle track is separated from both the pavement/sidewalk and the car lanes with curbs. Cycle lanes, just marked with a painted line, are very few in Copenhagen, but as a general rule they are as wide as the cycle tracks.

More than 95% of the cycle track users in Copenhagen are cyclists, in recent years even more. The rest are mopeds and low speed scooters, driving less than 30 km/h. In the following, "cyclists" also include users of mopeds and slow scooters.

1. Investigating cyclists' safety and feeling of safety

An investigation on cyclists' safety and feeling of safety/security in relation to cycle tracks, cycle lanes and various designs of intersections was asked for by Copenhagen politicians - and the investigation was carried out in 2006 by the Traffic Department with help from the Danish consultants Trafitec.

The investigation is a before/after study, comparing the accident situation before and after the establishment of a cycle track or other kind of cycling infrastructure. It takes into account the general development of traffic levels, as well as the general developments in the number of accidents and injuries. In the following both accidents and injuries are dealt with; accidents include injuries as well as accidents with just material damage. So when the two figures differ you could say that the injury figure is far the most important.

The study is not just confined to cyclists' accidents, but also includes pedestrian- and car accidents influenced by cycling infrastructure. Furthermore, intersections/crossings and road sections are investigated separately.

2. Main results of safety studies

The main results of the study of those road sections where cycle tracks have been constructed are:

- Cycle traffic has risen by about 20%, whereas car traffic has fallen by about 10% after the construction of the cycle tracks.
- Traffic safety has improved on road sections. Injuries have fallen by 4% and the number of accidents has fallen by 10% as a consequence of the construction of the cycle tracks.
- On the other hand, traffic safety has declined at intersections; there has been an increase in injuries by 18%.
- Cycle tracks have caused an increase in accidents of 9 – 10% on road sections and intersections combined.
- Cycle tracks influence cyclists' feelings of safety and security positively.
- Blue cycle crossings have a positive effect on safety but only if there is just one blue crossing in the junction area. In general, more than one blue cycle crossing has a negative effect.

So, cycle tracks have a positive effect on traffic safety, but there are safety problems at the intersections. However, the results should be seen in the light of a general decline in cyclists' accidents in Copenhagen. From 1995 to 2004, the number of serious accidents (KSI) has decreased from 231 to 124. At the same time, cyclists' risk per one million kilometres ridden has been reduced from 0.79 to 0.30.

3. The safety of cycle tracks

The construction of cycle tracks has resulted in a slight drop in the total number of accidents and injuries on the road sections between intersections of 10% and 4% respectively. At intersections on the other hand, both the number of accidents and injuries has risen significantly, by 18%. A decline in traffic safety at intersections has undoubtedly taken place after the construction of cycle tracks. If the figures for the road sections are combined with those for the intersections, an increase of 9-10% in accidents and injuries has taken place.

However, safety aspects of individual projects vary quite a lot and the safety aspects mentioned above should be taken with some reservations. The reason for this is that the total accident picture and the design of the road sections and the intersections vary on those individual streets where cycle tracks have been constructed.

The increase in injuries due to the construction of cycle tracks arises because there are more injuries to pedestrians and cyclists at intersections. There has been an increase of 28% and 22% respectively.

The accident picture or relationship between accident situations has changed markedly after the construction of cycle tracks. Many changes have taken place in various accident situations, with both rise and fall.

The construction of cycle tracks has resulted in three important gains in the field of safety: fewer accidents in which cars hit or ran over cyclists from the rear, fewer accidents with cyclists turning left and fewer accidents in which cyclists rode into a parked car.

Unfortunately, these gains were more than outweighed by new safety problems: more accidents in which cyclists rode into other cyclists (often when overtaking), more accidents with cars turning right, more accidents in which cars turning left drove into cyclists more accidents between cyclists and pedestrians as well as passengers exiting or entering busses.

4. Car parking and cycle tracks



Streets with cycle tracks. On narrow roads parking is often prohibited, and the cars have to cross the cycle lane and park on the side streets.

Prohibiting car parking when constructing new cycle tracks causes more accidents and injuries. This is due to cars being parked on side streets instead, with a consequent increase in turning traffic and thus more conflicts between cars and bicycles. This especially applies at right of way regulated intersections. The construction of cycle tracks and prohibition of parking resulted in an increase in accidents and injuries at intersections of 42% and 52% respectively. The construction of cycle tracks combined with permission to park also resulted in an increase in accidents and injuries but of only 13% and 15% respectively.

When constructing new cycle tracks, car parking conditions have a great influence on the number of accidents. A section of 80-90 meter can potentially accommodate some 15-20 parked in two road sides. This equals 100-200 car movements into side streets, causing a substantial increase in the number of turning cars and thereby conflicts between cars turning and bicycles going straight on.

On road sections with no parking, there was a 24% increase in accidents, whereas on stretches where parking was permitted the accident rate fell by 14%. Parking conditions are not thought to affect the number of injuries on these road sections, since these fell by 9% and 8% respectively with regard to no parking or parking permitted. When parking is permitted, there are fewer parking accidents, collisions when backing or accidents to pedestrians. Illegally parked cars cause more accidents than legally parked cars. The width of the driving lanes is reduced when parking is permitted, resulting in increased safety for pedestrians when crossing the road.

5. Shortened or advanced cycle tracks

At signalised intersections, it has been found that the number of accidents from approach lanes with a shortened cycle track fell by 30%, whereas the number of injuries increased by 19%. A significant improvement in car drivers' safety occurred when a shortened cycle track was constructed, whereas cyclists' and especially pedestrians' safety deteriorated.

The accident rate for approach lanes with an advanced cycle track increased significantly, by 25%, whereas injuries increased by only 9%. The increase in accidents is due primarily to more material damage, involving only cars, together with right-turn-accidents. The accident rate for approach lanes with an advanced cycle track without turn lanes for cars increased by 68% for accidents and 67% for injuries. The figures for approach lanes with turn lanes showed a 15% increase in accidents and a fall of 5% in injuries.

A comparison shows that approach lanes with an advanced cycle track without separate turn lanes for cars is the design that functions worst. Shortened cycle tracks and advanced cycle tracks with turn lanes for cars are equally effective as far as safety goes. There is this difference however: advanced cycle tracks are best for pedestrians and cyclists, whereas shortened cycle tracks are best for car drivers.



Shortened cycle track extended into a right turn-lane (left foto), a shortened cycle track extended into a narrow lane (middle) and an advanced cycle track with a blue cycle crossing and a pre-green light for cyclists (right).

6. Safety of cycle lanes

The construction of cycle lanes has resulted in an increase in accidents of 5% and 15% more injuries. The decline in traffic safety can be seen both at intersections and on road sections. The increases occurred especially amongst cyclists where the increase in injuries is amounting to 49%.

The construction of cycle lanes has a markedly different effect on the accident statistics compared to the construction of cycle tracks. The construction of cycle lanes did not apparently lead to an appreciable fall in accidents between cars driving straight ahead and bicycles going in the same direction, or accidents between cycles and other traffic. Conversely, the construction of cycle lanes did not apparently lead to an appreciable increase in accidents between bicycles and pedestrians or accidents between cars turning left and cycles.

The number of accidents involving cars turning right increased by 73% with the construction of cycle lanes. There was also a considerable increase in accidents between cyclists going straight ahead and other cyclists going in the same direction.

7. Safety of blue cycle crossings

There was a 13% decrease in accidents at intersections where only one blue cycle crossing had been laid down. At those intersections where two or four blue cycle crossings had been laid down however, increases of 23% and 61% respectively occurred. Corresponding changes in the number of injuries for one, two and four blue cycle crossings are a fall of 22%, and increases of 37% and 138% respectively. A special version of two blue cycle crossings is one crossing at right angles to another in a 3-way intersection. In this version, there was a fall in accidents and injuries of 37% and 69% respectively.

If more than one blue cycle crossing, there is a clear relationship between the number of these and the number of cycle and car accidents. The more blue cycle crossings, the greater the risk of these two types of accidents. The more roads joining an intersection, the less the safety effect of the blue cycle crossings, irrespective of the number of blue crossings laid down and the intersection's size. The size of the intersection and the amount of incoming car traffic does have a significance. The smaller the intersection is, the safer it is, when one blue cycle crossing is laid down or two blue cycle crossings at right angles to each other.

At a junction with one blue cycle crossing, the creation of the crossing has been especially advantageous in terms of safety for cyclists who have used the cycle crossing in the post-study period, as well as for pedestrians on the pedestrian crossing immediately next to the blue cycle crossing. For these groups, the number of accidents and injuries fell by 37% and 44% respectively. A fall of 52% also occurred in accidents involving cars turning right.

The signalling value provided to traffic users by a blue cycle crossing is also beneficial in terms of safety. The smaller the junction is, the greater the influence on the accident figures this signalling value acquires and the more traffic users focus upon those problems of which the blue cycle crossing is trying to warn them. The same is true when there are two blue cycle crossings at right angles to each other.

At intersections with two parallel or four blue cycle crossing the signalling value is judged to be lost. Here, cyclists and car drivers drive over on red more often after blue cycle crossings have been laid down and there are more frequent examples of rear end collisions.

8. Safety of side road junction cycle track crossovers



Side road junction with elevated cycle track crossover

The construction of side road junction cycle track crossovers has brought about a slight decline, 5%, in the number of accidents. With the construction of these crossovers, the number of accidents between pedestrians and motor vehicles has fallen, by 54%. Accidents involving cyclists has fallen slightly, by 12%, while accidents involving only motor vehicles has increased slightly, by 11%.

At T-junctions, the number of accidents increased slightly, by 10%, while accidents at intersections fell slightly, by 18%. The safety factor was higher at intersections than T-junctions in all accident categories: pedestrian, cycle and car.

Nothing indicates that the type of crossover has any significance as far as safety goes. A pavement crossover, where the pavement on the main road is slightly elevated over the junction with the side road, has just as high safety effect as a cycle track crossover, where both pavement and cycle track are elevated over the junction with the side road.

The construction of crossovers has an influence in three accident situations. Accidents between left-turning-cars and other cars increase by 70%, while accidents between left-turning-cars and pedestrians/cyclists and accidents between pedestrians and non-turning-vehicles fall significantly by 49% and 51% respectively.

In the study of cycle tracks, the construction of crossovers can indirectly be evaluated by comparing the effects of constructing continuous (with a crossover) and interrupted (without a crossover) cycle tracks at right of way regulated intersections. The construction of continuous tracks resulted in an increase in accidents and injuries of 30% and 81% respectively at 3-way intersections. The figures for interrupted cycle tracks showed increases of 34% and 343% respectively. At 4-way intersections, the number of accidents remained unchanged with the construction of continuous cycle tracks, whereas the number of accidents increased by 92% with interrupted cycle tracks. If the parking situation and the breadth of the side road are taken into consideration, it could be said that continuous cycle tracks (with the construction of crossings) are safer than interrupted cycle tracks at both 3- and 4-way right of way regulated intersections.

9. Effects upon traffic volumes

The construction of cycle tracks has brought with it an 18-20% increase in cycle traffic and a decrease of 9-10% in car traffic on those roads where cycle tracks have been constructed. This is a statistically significant and very positive effect of new cycle tracks in Copenhagen.

The construction of cycle lanes resulted in a 5-7% increase in cycle traffic and an unchanged amount of car traffic on those roads where cycle lanes were laid down.

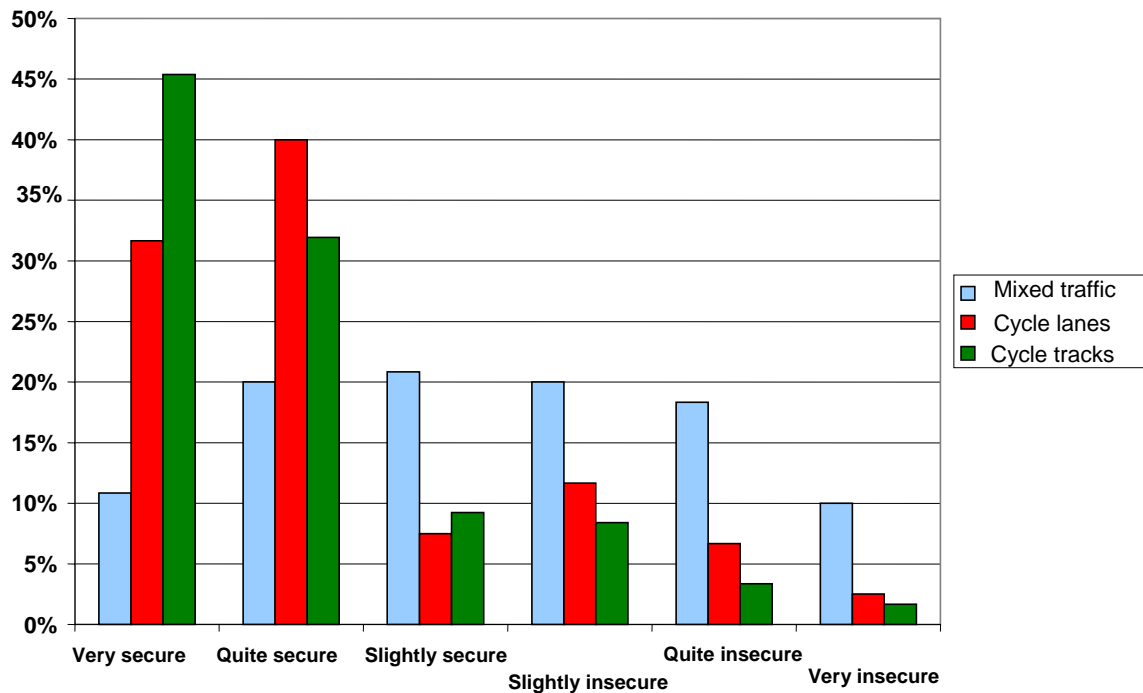
10. Cyclists' perceived security

Cyclists feel most safe on roads with cycle tracks and most insecure on roads with mixed traffic. This is true for all cyclists, irrespective of their gender, age, purpose in cycling or familiarity with their route. The figure shows that conditions in mixed traffic create considerably more feelings of insecurity than conditions on cycle tracks or cycle lanes. Cycle lanes are a middle path so to speak: somewhat less secure than cycle tracks, but considerably more secure and satisfactory than mixed traffic. Increased car traffic leads incidentally to cyclists feeling more insecure.

Cyclists feel safest at signalised intersections with a blue cycle crossing, whereas, somewhat strangely, cycle facilities immediately in front of the junction do not seem to have real significance. This can possibly be attributed to the fact that 10 metres after the junction (where cyclists were interviewed) cyclists have forgotten the conditions immediately in front of the junction. Nothing indicates that any of the three lay-outs - cycle track to stop line, shortened cycle track or narrowed cycle lane - influences the cyclists' feeling of security. It seems as if it is the conditions within the junction itself which create differences in the cyclists' perceptions. A blue cycle crossing makes cyclists more secure and satisfied, while increased car traffic and junction size make cyclists more insecure and dissatisfied.

62% of cyclists answered that in general they feel secure in the traffic of Copenhagen. This is close to the result of the Copenhagen Bicycle Account 2004. 58% of cyclists said that they felt safe when cycling in Copenhagen. This figure can be compared to the current investigation showing that 87% feel secure on road sections with cycle tracks and 86% feel secure at intersections with advanced cycle tracks and blue cycle crossings.

proportion of cyclists



Cyclists feelings of security on road sections with mixed traffic, cycle lanes and cycle tracks.

11. The principal results and what the City of Copenhagen can do

Cyclists feel most secure on cycle tracks and least secure in mixed traffic. Cycle lanes are a middle way. At intersections, the conditions within the intersection itself seem to be most significant in determining cyclists' feelings of security. One single blue cycle crossing increases cyclists' security, whereas more car traffic and a larger intersection area increase insecurity.

Taken in combination, the cycle tracks and lanes which have been constructed have had positive results as far as traffic levels and feelings of security go. Because of problems in the intersections, they have however, had negative effects on safety.

The increase of cycling (and decrease of car use) resulting from the construction of cycle tracks will undoubtedly result in gains in health from increased physical activity. These gains are much, much greater than the losses in health resulting from a slight decline in traffic safety.

It is possible to reduce the decline in traffic safety of all types of traffic in one go as the study has shown in relation to cycle tracks and especially cycle lanes ; maybe safety can be improved in the future since safety factors are clearly dependent on a number of design factors and regulatory conditions. A safe construction of cycle tracks:

- avoids reducing possibilities for car parking
- avoids approach lanes without turn lanes at signalised intersections
- creates one and only one blue cycle crossing at signalised intersections
- extends cycle track crossovers into crossings at right of way regulated intersections
- limits the use of cycle lanes

It should be noticed that blue cycle crossings, retracted stop lines and pre-green lights for cyclists have been used in only very few places on those streets where cycle tracks have been constructed in Copenhagen in the after-period of the investigation. More extended use of these measures would very probably have improved traffic safety when establishing new cycle tracks. The Traffic Department has just checked all intersections to ascertain where retracted stop lines for cars have not yet been laid down, a step which can be expected to improve cyclists' safety.

Parts of the cycle track network should be checked, a step which is taken into account in the Cycle Track Priority Plan 2006 – 2016. Road sections and intersections must be taken together with regard to improving cycling conditions. Car drivers' and pedestrians' safety should also be taken into consideration to a larger degree. In actual practice, local considerations should be taken into account when deciding whether the current solution is appropriate or not.

Security, safety and smooth traffic flow on road sections and at intersections are taken into consideration in connection with the design of cycle tracks etc. in Copenhagen, since all three are important for the quality of cycling as a mode of transport. The Transport Department is therefore working to find a safe, secure and smoothly flowing traffic design for cycle tracks at intersections.

The solution could possibly be a retracted cycle track with a narrow cycle lane over the last 15 – 20 metres up to the intersections. The cycle lane is about 1.5 metres wide and has the advantage that it can be combined with a retracted stop line for cars and possibly a blue cycle crossing. This solution can be found a few places in the City of Copenhagen and is commonly used in Frederiksberg (a neighbour municipality).

The Technical and Environmental Committee of Copenhagen decide annually where and how money is to be invested to improve traffic safety. The political interest in improving cycling conditions, includes the construction of new cycle tracks and a substantial part of the new investments granted for 2007 – 2009 (amounting to DKK 3 x 25 million) will be used on improvement of intersections.