Bus Stop Access
along the Dyke Road in Hanoi

Final Report for Hanoi Ecotrans

- Subproject Bus Stop Access -

Orderer: City of Hanoi - Vietnam

Contractor: Institute of Transport,
Road Engineering and Planning –
Leibniz University of Hannover

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Hanoi Ecotrans – Bus Stop Access

Final Report
by order of the City of Hanoi - Vietnam

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Content

1 Introduction

1.1 Content of report

Content of this draft report is the constructional rearrangement of a road section of the highly used dyke road in Hanoi, partly having six lanes, between the intersection at the Long Bien Bridge in the north and the intersection Tran Khanh Du / Tran Hung Dao in the south. (A closer description of the study area as well as of the road itself can be found in paragraph 2.1) Because of the road's not well adapted layout pedestrians and cyclists as well as bus passengers accessing and leaving the bus stops are forced to use dangerous and sometimes overloaded road crossings. Furthermore, these crossings are in parts not coordinated with the installations of public transport. At the Long Bien Bridge the construction of an important interchange bus stop is planned. In this context a possible concept for the realization of a Bike-and-Ride-facility is still missing.

Even though this study was motivated by the special needs of bus passengers accessing and leaving busses along this road stretch, the improvement of their situation cannot be aimed at without respecting the needs of other road users, too. Planning must always have in mind the needs of all user groups using a road section (holistic design). Furthermore, bus passengers are mainly pedestrians and cyclists as well when accessing and leaving the bus stop. Therefore, the design proposal developed in this report suits the needs of all road users. However, the needs of non-motorized traffic are highlighted since motorists are strongly favoured by the present design, leading to severe problems for non-motorized road users.

The measures that are proposed within this report must be considered to be short-term measures that can be realised rather quickly. Since these measures promise to improve the stressed situation described in this report within a short period of time they have been preferred to long-term measures that can be implemented only along with other plannings of the city of Hanoi on a much larger scale and affecting the city's whole street network. However, the proposed measures will also be suitable when traffic on the examined dyke road possibly decreases in the future due to possible modification of the road network.

1.2 Proceeding

The proceeding of this work follows the traffic planning process as defined by the German "Forschungsgesellschaft für Straßenwesen und Verkehr (FGSV)". This process is shown in figure 1.

During the stage of pre-orientation, problems of a certain situation are identified on a very general level, creating the need for a closer examination. Thus, the pre-orientation is never part of a project itself but motivates and justifies it. The study starts with the stage of **problem analysis** which is described in chapter 2. In a first step the planning area will be presented in paragraph 2.1, followed by an overview of the guidelines and objectives that shall be respected when assessing the present state and identifying and choosing possible solutions (see paragraph 2.2). Paragraph 2.3 deals with the analysis of the present state without anticipating its assessment. This means that this paragraph is a plain description of the situation along the dyke road as it is found right now. Afterwards, deficiencies can be clearly identified by comparing the system of objectives and the analysis of the present state. The results of this step are shown in paragraph 2.4.

Chapter 3 deals with the **analysis of measures** that are to improve the situation found in chapter 2. After a first introduction to this chapter (see paragraph 3.1) possible measures will be identified in paragraph 3.2. In a first step, common design elements for various user groups are presented along with their specific characteristics, followed by a description of the chosen elements for the examined corridor and the reasons why these elements have been chosen in this special case. The appraisal of the design for the whole stretch of the dyke road which is assembled by these chosen elements follows in paragraph 3.3, giving an overview of the expected impact of all measures combined.

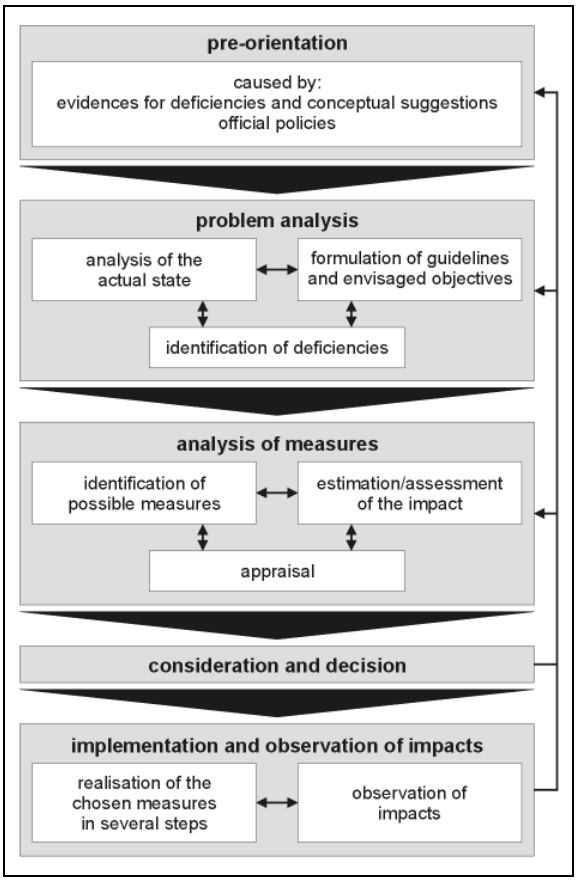

figure 1: traffic planning process (FGSV, 2001[1])

The following stages shown in figure 1, again, are not part of this study but represent the stages of consideration and decisions that have to be made by the responsible decision-makers as well as the implementation of measures and the observation of their impacts. Thus, these stages take place after the study is finished.

2 Problem Analysis

2.1 Presentation of the planning area

The planning area is shown in figure 2. The **road section** analyzed in this report leads from Long Bien Bridge and its surroundings in the north (1) to the intersection Tran Khanh Du / Tran Hung Dao in the south (3), passing a flyover junction at Chuong Duong Bridge (2), leading to the eastern bank of the Red River. The road can be classified as an arterial urban highway and is of high importance for the city as well as for the regional and supra-regional network. The traffic is guided on two multiple-lane roadways which are located on different heights and separated by a wide central reserve. The higher roadway leading to the north is located on the dyke that protects the city from flooding by the Red River. The number of lanes for motorized traffic varies between two and four lanes southbound and between two and three lanes northbound. A wide bicycle lane without physical separation from the motorized traffic exists in both directions.

[1] Forschungsgesellschaft für Straßen- und Verkehrswesen: Leitfaden für Verkehrsplanungen – Ausgabe 2001 (Guidelines for Transport Planning). Cologne, 2001

figure 2: planning area dyke road

On the **western roadside** of the dyke road the densely populated Old Quarter is to be found, as well as the city centre in general with all common activities such as dwelling, vending, banks, services, restaurants, tourism etc. Thus, many destinations and origins for daily trips can be found here.

Some interesting facts about the **quarter on the eastern side** of the dyke road are revealed in a HAIDEP report dedicated to this topic[2]. This report covers a larger section of the dyke quarter than what is covered by the present study. The HAIDEP report includes the three wards Yen Phu, Phuc Xa and Phuc Tan while only the latter and most southern is considered in the present study. However, a good general impression can be obtained by the HAIDEP report even for this study whose planning area is more limited.

The HAIDEP report outlines the fact that the whole area on the eastern side of the dyke road is a flooding area of the Red River. The average water level of 4.0 to 7.0 meters during the seasons can rise up to 11.6 meters (5-year return period) and 14.0 meters (125-year return period) even though the situation varies from place to place. Despite this fact, the area attracted many migrants coming to Hanoi since “doi moi” in 1986. Since then it grew fast and became an important but unplanned area for settlement. The HAIDEP report indicates a number of approximately 160.000 inhabitants for all three mentioned wards, leading to an extremely high density of occupation. This amount is still growing. Figures for the Phuc Tan ward, which is part of the planning area of the present study, are quoted to be at 14.830 inhabitants in 2003 and at a net density of 327.0 persons/ha.

The HAIDEP report underlines the semi-legal status of most residents. Due to its unplanned development the whole area is mainly characterized by low quality buildings and includes some “slum-like” and unhealthy sections. The infrastructure is not satisfactory, providing only narrow streets and especially a bad drainage. However, there have been infrastructure upgrading projects recently. Up to today, schools, kindergartens, companies and some industrial facilities as well as public and social authorities, cultural centres and health clinics have been installed there. The Phuc Tan Stadium and the Long Bien Market at Long Bien Bridge are important places for the area as well. Thus, not only the residential function of this area is of importance today, but its usage is much more differentiated nowadays. According to an assumption by the project partners in Hanoi, the area will become a living quarter of high level in the future.

Due to the construction of the dyke road in the 1990s, the dyke quarter is now rather isolated from the rest of the city. The large dimensions of the road, its high traffic loads and the limited possibilities for non-motorized persons to cross it prevent an adequate connection between the two sides of the road. This is especially crucial when considering the sketched past and possible future development of this area and its high and still increasing number of inhabitants. Entering and leaving the dyke quarter within the planning area is possible at six junctions where the protective wall of the dyke that accompanies the eastern roadway is interrupted. The entrance to the market at Long Bien Bridge is another possibility to enter the quarter. Furthermore, there are five independent staircases surmounting the protective wall

[2] Pascal Lavoie, Hoang Long, Dao Minh Ngoc: HAIDEP Pilot-Project on Improvement Plan and Strategy for a Priority Action Area (Final Report for Phase 1). Alliance Architecture (Vietnam). Hanoi, 2006

along the course of the road, allowing pedestrians to access and leave the dyke quarter at places other than junctions. The situation calls for a better connection of the quarter to the rest of the city. It is therefore important to install suitable road crossings to the western roadside for non-motorized traffic and pedestrians.

Besides the described situation that must be one of the main aspects when rearranging the dyke road, **public transport** along this section and at Long Bien is another criterion of high importance. The course of the dyke road is part of many bus routes running through Hanoi. A look at the 2006 Hanoi Bus Map[3] reveals that 17 bus routes (2, 3, 4, 8, 10, 11, 15, 17, 18, 19, 22, 23, 24, 31, 34, 35, and 36) run on some or all parts of the examined road stretch. Project partners in Hanoi state the number to have increased to even 19 bus routes at present. According to the website of Hanoi's bus operator Transerco[4] most of the bus routes provide service between 5.00 am and 9.00 pm. Ten routes are operated at a frequency of 15 to 20 minutes. The frequencies of the other routes vary mainly between 10 and 20 minutes. Two routes sometimes even reach a maximum frequency of five minutes. This leads to a huge number of buses travelling along the examined dyke road section per day. Project partners in Hanoi speak of 3.444 courses per day.

A very important point not only for public transport can be found at **Long Bien** where lots of bus routes pass and stop. This location has also importance for bus changing passengers. That is why the construction of a large Interchange Bus Stop is envisaged by the Hanoi project partners. Designs have already advanced and include the reconstruction of the whole junction at Long Bien Bridge that has to deal with lots of traffic coming from all sides, amongst others motorcyclists and cyclists coming from and going to Long Bien Bridge via ramps. Furthermore, a night market takes place at this location every day in the early morning hours that must be considered by providing enough space.

Besides the rearrangement of Long Bien that is mainly planned and developed by the project partners in Hanoi, **bus stop access** along the rest of the examined dyke road must be considered as well. At present there are four bus stops southbound and four bus stops northbound at the curb. The location of each bus stop is shown in figure 3. Even though the number of bus stops is the same for each direction, they are not equally spread and in all but one case not on opposite sides of the road but at completely different places. This problem must be addressed. And just as for pedestrians and cyclists, the situation for bus passengers wanting to reach a bus stop on the other side of the road is equally unsatisfying due to a lack of safe crossings.

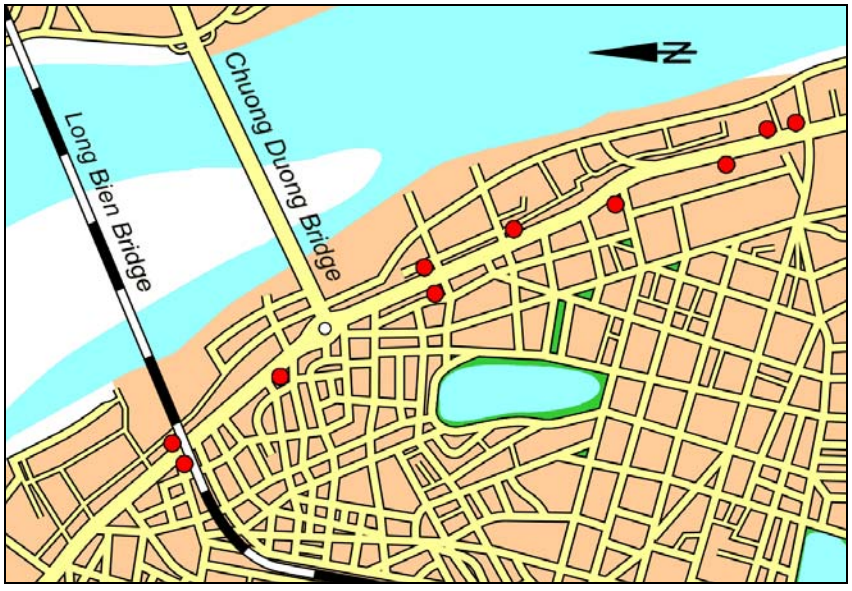

figure 3: present locations of bus stops

[3] Hanoi Bus Map. Transport Management & Operation Centre (TramOc). Hanoi, 2006

[4] Hanoi Transerco Website: http://www.hanoibus.com.vn status: January 2007

When rearranging a road, **future planning** has also to be kept in mind. According to the project partners in Hanoi there are plans for the construction of new bridges over the Red River at other locations outside of the planning area of this study. Once completed, these bridges would provoke decreasing traffic volumes on the dyke road which would be favourable for improving the present situation. A more detailed master plan for Hanoi could not be made available for this study. However, the above mentioned plan should not be neglected when making propositions. Nevertheless, as already emphasized in paragraph 1.1, this study will present economic measures for a rather short-term rearrangement of the dyke road that will contribute to a quick improvement of the situation for non-motorized traffic and bus passengers and at the same time still handles the high traffic volumes of motorized traffic. A rather fast solution must be considered to be very favourable, given the present situation. On the other hand, the proposed measures can also cope with future plans that come along with an increase of traffic volumes.

2.2 System of objectives

Before one can identify possible measures for a rearrangement, and even before the present state is analyzed in detail and assessed, the objectives that the envisaged improvement shall aim at must be clarified. Therefore, a system of objectives must be developed which contains all the important aims. Within this system of objectives, each objective and criterion has to be weighted since in most cases one design can never favour all the needs of different groups of road users in the same way due to limiting constraints. Therefore the most important aspects for a special task have to be identified in a first step.

German guidelines on urban road design[5] give an orientation on different aspects that should be considered for a holistic design. The system of objectives shall contain the four main objects “traffic”, “precincts/environment”, “design of street space”, and “cost-effectiveness”. Within these objects, all objectives applicable for this study are shortly described and weighted below and shown in table 1.

Within the first object “**traffic**”, a highly important objective must be traffic safety. This can be assessed by examining accident rates and the speed behaviour of motorized traffic. Both can not be expressed in precise figures within this project, but decreasing accident rates and an adapted speed should be an objective that must be strongly supported by the design.

Another objective of importance is a good quality of traffic flow that has to be regarded for all user groups separately. Public transport is of high importance within this project and the design should favour both the accessibility of bus stops as well as the quality of conveyance for passengers in the buses. Motorized traffic must not be neglected within this project since the dyke road is of high importance within the urban, regional and even supra-regional road network. However, motorcyclists are dominating the road at present and do not leave much space for other road users. Furthermore, the main goal is to improve the situation for pedestrians, cyclists and bus passengers. Thus, for the safety of all these road users, an adequate reduction of driving comfort for motorcyclists can be accepted. The quality of traffic flow for cyclists, again, is rated to be of high importance, for crossing cyclists as well as for those travelling along the course of the dyke road. Pedestrians, whose needs are equally important within this study, are also of high importance, but their need for crossing dominates the need of walking along the road. The latter is thus only of medium importance since most pedestrians leave directly to the surrounding western and eastern quarters.

For those road users starting and ending their trips along the road with different modes, a good coverage of the area must be assured. Along the western roadside, there are many shops, banks and other facilities and the sidewalk is used for a variety of activities including parking. On the other side of the road, parking along the road is of no importance at all. Therefore, all in all it is at least of medium importance to provide good and enough parking facilities. For those travelling by bus, the quality of the coverage of bus stops is of high importance in this study.

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[5] Forschungsgesellschaft für Straßen- und Verkehrswesen: Empfehlungen für die Anlage von Hauptverkehrsstraßen – EAHV 93 (Recommendations for Urban Main Road Design). Cologne, 1993

First objective of the second main object "**precincts/environment**" is a preferably low consumption of space, which is expressed by the dimensions of the traffic area. Even though it must not be neglected either, this aim is considered to be of only low importance for this project if compared to the more urgent objectives within the field of traffic quality.

The design must favour a high social serviceability. Due to its separating effect, the dyke road does not fulfil this aim at present. Reducing the separating effect is one of the most important aims in this project. By contrast, a good amenity value is always desirable but of no high importance here.

The quality of the **design of street space** can be judged by its impact on the objectives to provide a good orientation for road users as well as on the objective to offer high animation and a balanced composition. The first objective is considered to be of less importance since the stretch of the dyke road does not trouble one's personal orientation in a special way. The second objective is of rather artistic importance and is deferred to the more important objectives causing the need for a rearrangement of the road.

As a last point, **cost-effectiveness** is considered to be of high importance for the designs since proposed measures should be implemented fast in order to facilitate the situation for non-motorized road users and bus passengers as soon as possible. A quick implementation is clearly favoured by more economic solutions.

object	objective		assessment criterion
traffic	traffic safety		gravity of accidents/accident rates
			speed behaviour of motorized traffic
	good quality of traffic flow	public transport	accessibility of bus stops
			quality of conveyance
		motorized traffic	quality of driving comfort
		cyclists	quality of driving comfort
			quality of crossing comfort
		pedestrians	quality of walking comfort
			quality of crossing comfort
	good coverage of the area		parking facilities
			quality of bus stops
precincts/environment	Low space consumption		traffic areas
	social serviceability		low functional separating effect
			amenity value
design of street space	orientation		recognition of direction and distance
	animation and composition		creation of space, scale and proportions
cost-effectiveness	High cost-effectiveness		investment

table 1: system of objectives (green = high importance, yellow = medium importance, red = low importance)

2.3 Analysis of the actual state

A first presentation of the planning area has been given in paragraph 2.1. In a next step, the actual state of the dyke road must be analyzed in detail. It must be highlighted again, as already pointed out in paragraph 1.2, that this step of the planning process is just a plain description of the state without assessing it. The identification of deficiencies, which can be derived by comparing the actual state to the made up system of objectives follows in paragraph 2.4. In order to make all observed aspects clearly visible and not to extend this report too much, the analysis of the actual state is presented by using bullet points. A plan of the actual state of the dyke road is given in the appendix (plan: actual situation).

2.3.1 General information

- main road serving as urban highway, but also lingering on the western sidewalk and utilization for businesses of different kinds
- western road side: mixed land development (enterprises, hotels, banks, boundary of the Old Quarter)

- eastern road side: dyke wall and dyke quarter behind (residential buildings with two to four storeys, companies, restaurants, small shops and service providers)
- total width of street space about 45.0 to 50.0 m on the average
- two roadways (northbound two to three lanes, southbound four lanes)
- eastern width of street space about 14.0 m on the average, western width of street space about 22.5 m on the average
- one central reservation (parking, bus parking bays, gas station, pylons for high-voltage power line)
- covered by several bus routes
- important junction and bus stop at Long Bien Bridge
- night market at Long Bien Bridge with delivery traffic

2.3.2 Traffic volume and safety

- considerably high traffic volumes for motorized traffic

  (Traffic counts provided by the project partners in Hanoi indicate traffic volumes on the northern section of the examined stretch of the dyke road to reach values of 8.592 motorcycles and 918 cars and trucks northbound and of 8.040 motorcycles and 1.410 cars and trucks southbound in the morning peak hour which is not defined more precisely. While these figures have to be used carefully since the respective count must be considered to be not very accurate, they give nevertheless a general impression of the definitely high traffic volumes on the dyke road.)

- 17 to 19 bus routes serving the examined stretch of the dyke road with up to 3.444 courses per day
- high crossing demand for non motorized road users

  (The project partners in Hanoi accomplished a traffic count at each entry to the dyke quarter exclusively for this study. The counting points include all junctions that can be used by all road users as well as stairs for pedestrians surmounting the dyke wall at places other than junctions. The counting points can be seen in figure 4. The results of the counts are shown in figure 5 to figure 10. Volumes are given in vehicles, pedestrians and cyclists per hour in the respective peak hour. Morning counts have been done between 7.00 and 9.00 am and afternoon counts between 4.00 and 6.00 pm. The figures show the values of two consecutive half hour intervals that sum up to the highest traffic volume per hour within the counting period. Therefore, the exact peak hour for each value varies within the boundaries of the counting period according to the surveyed values at each counting point and for each mode. As especially figure 9 and figure 10 show, all junctions and especially the junction at counting point 7 with up to 800 persons per hour are of high importance for non-motorized road users to enter and leave the dyke quarter and thus to cross the road. The stairs are also highly used by pedestrians, especially those in the north at Chuong Duong Bridge and Long Bien Bridge where people want to reach the Old Quarter or Long Bien.)

- lower demand for pedestrians walking along the road (after crossing the road, people rather tend to leave it immediately and go to the city centre or to the dyke quarter)
- no accident data available for the planning area, but a generally high accident rate in Hanoi and most likely along the dyke road

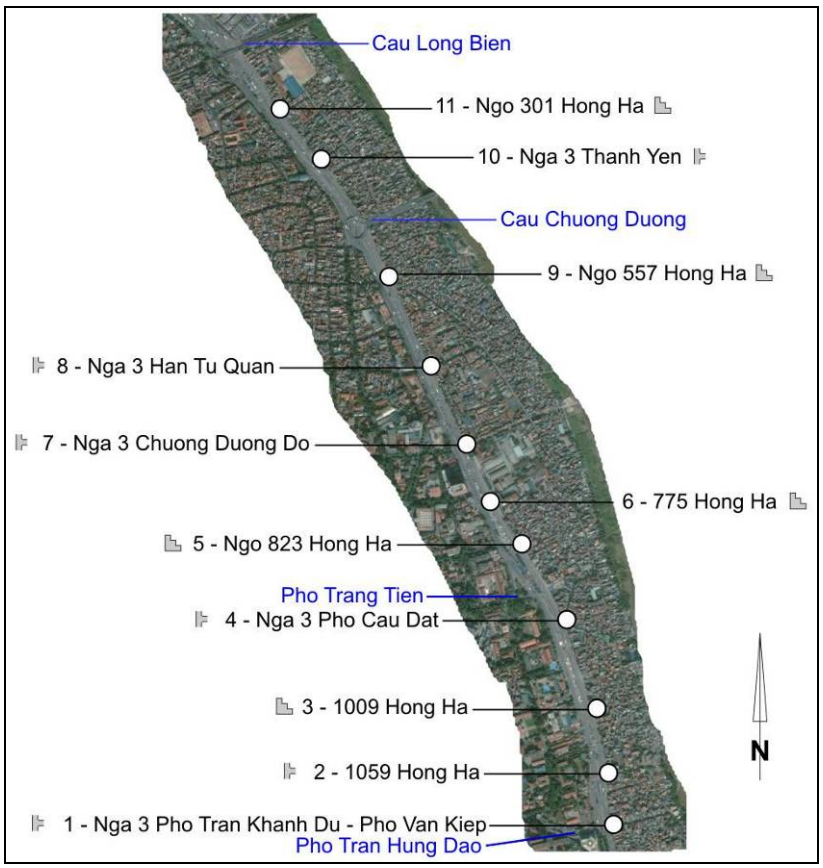


figure 4: counting points at the entrances to the dyke quarter (differentiated as stairs and junctions)

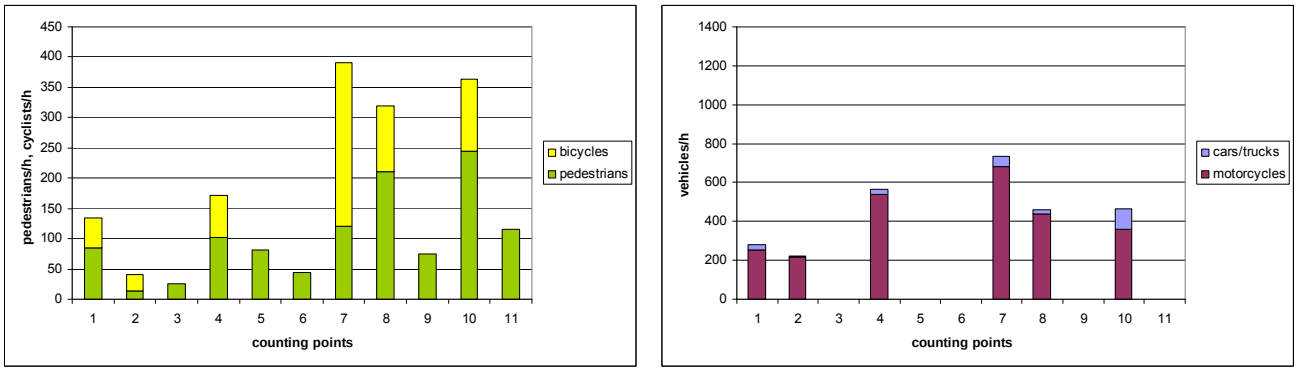


figure 5: outflow from the dyke quarter in the morning peak hour (counts between 7.00 and 9.00 am)

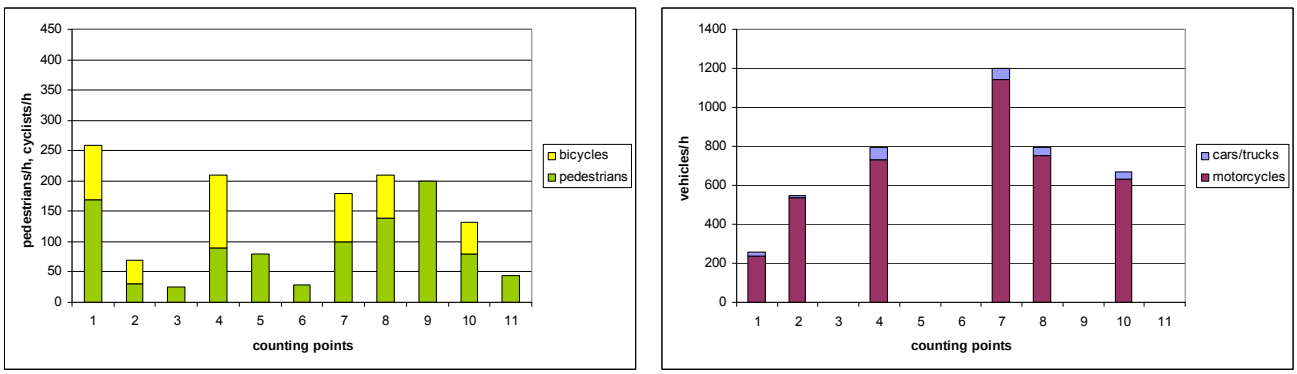


figure 6: inflow to the dyke quarter in the morning peak hour (counts between 7.00 and 9.00 am)

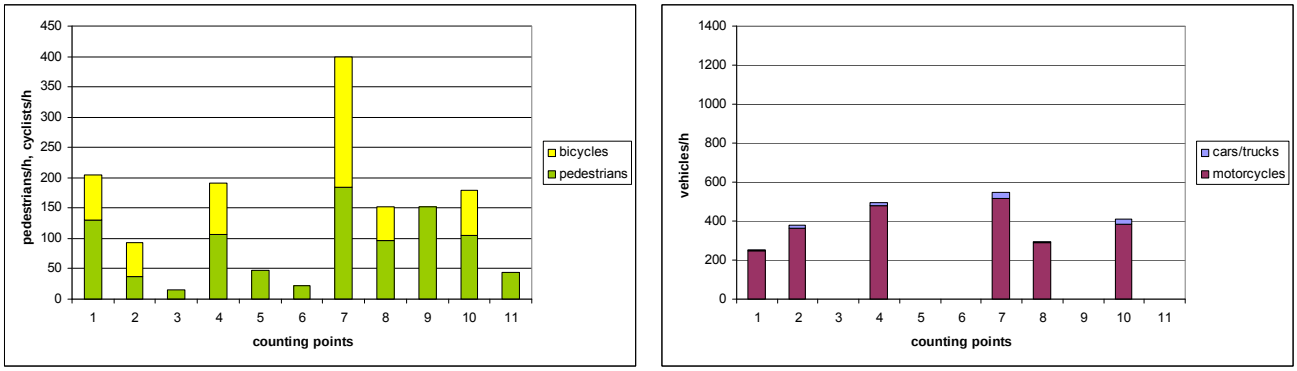


figure 7: outflow from the dyke quarter in the afternoon peak hour (counts between 4.00 and 6.00 pm)

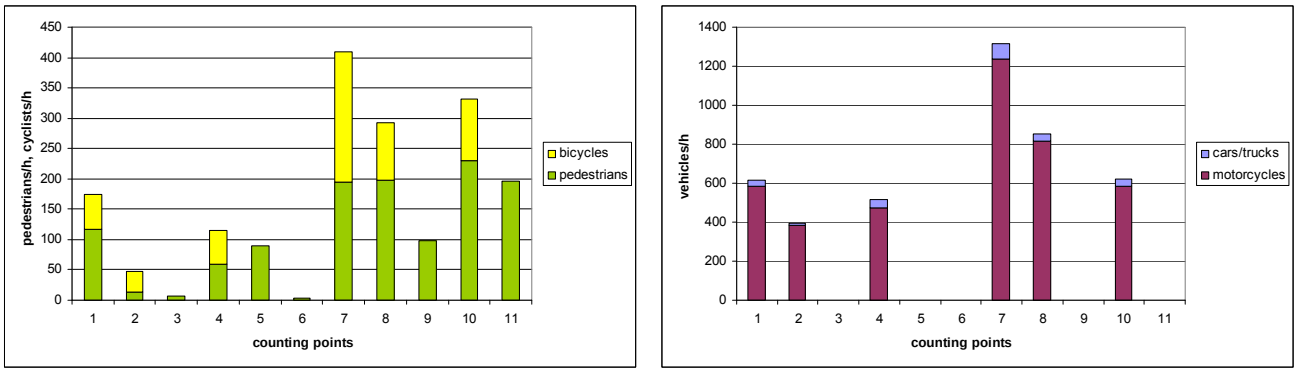


figure 8: inflow to the dyke quarter in the afternoon peak hour (counts between 4.00 and 6.00 pm)

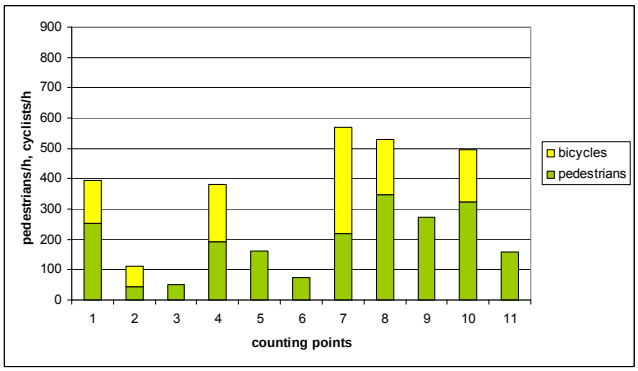


figure 9: total inflow and outflow of non-motorized traffic to and from the dyke quarter in the morning peak hour (counts between 7.00 and 9.00 am)

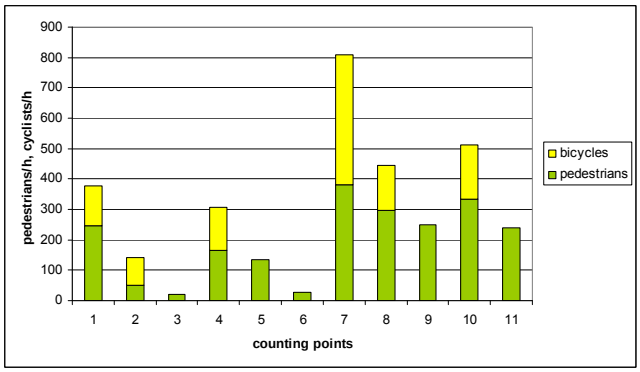


figure 10: total inflow and outflow of non-motorized traffic to and from the dyke quarter in the afternoon peak hour (counts between 4.00 and 6.00 pm)

2.3.3 Pedestrians

- eastern roadway: sidewalk of about 1.5 m width on both sides, bounded by protecting wall or railing
- western roadway: one sidewalk of 2.0 to 5.0 m width
- crossings → see paragraph 2.3.5
- pedestrian traffic volumes → see paragraph 2.3.2

2.3.4 Cyclist

- in both directions one-directional bicycle lanes of 2.0 to 5.0 m width (see figure 11)
- interruption of bicycle lanes at intersections without assigned crossings (see figure 12)
- in the area of Chuong Dong Bridge independent bicycle path implemented as underpass
- crossings → see paragraph 2.3.5
- bicycle traffic volumes → see paragraph 2.3.2

figure 11: bicycle lane of large width

figure 12: interruption of the bicycle lane at an intersection

2.3.5 Crossing installations

- most of the crossing installations are implemented as zebra crossings (see figure 13), sporadically as traffic lights
- high crossing demand at entrances to the dyke quarter (see paragraph 2.3.2)
- high crossing demand of bus passengers going to and leaving the bus stops
- separately marked (but ignored) crossings for cyclists only at the Long Bien Bridge (see figure 14)
- crossing of the central reservation possible in the area of ramps or staircases only because of the different levels of the roadways (see figure 15 and figure 16)

figure 13: pedestrian crossing passing four lanes

figure 14: marked crossing for cyclists in the area of Long Bien Bridge

figure 15: staircases at the central reservation in order to allow surmounting the height difference

figure 16: bicycle ramp to allow crossing the central reservation

2.3.6 Public transport

- public transport along the whole section (see also paragraph 2.1 and 2.3.2)
- bus stops at the curb on the level of the sidewalk
- 5 bus stops southbound and 5 bus stops northbound
- bus stops for both directions on opposite sides of the road only at two places
- distances between bus stops vary between 410 and 790 m southbound and between 200 and 1,200 m northbound (see also paragraph 2.1)
- some bus shelters at bus stops on the western roadside, no bus shelters on the eastern roadside
- waiting area on the sidewalks
- in the south: start and terminal bus stops of some routes implemented on the central reservation

2.3.7 Parking

- high parking demand
- parking on the central reservation (mainly cars, busses and lorries)
- in the south: parking bays for busses on the central reservation
- in the side area: unofficial parking of motorcycles, cars and lorries on the sidewalk and on the bicycle lane, some with official marking, too (see figure 17 and figure 18)

figure 17: use of side area as parking space by motorcycles

figure 18: use of side area as parking space by lorries

2.3.8 Planting vegetation

- planting of trees and grass mainly on the western roadside, especially in the area of a large triangular island

2.4 Identification of deficiencies

After the actual state of the dyke road has been elaborated, the identification of deficiencies can be done by comparing it to the system of objectives that has been derived in paragraph 2.2. The result of this step is described in this paragraph, again by using bullet points for the sake of shortness of this report. While the following text gives an overview of the general deficiencies of the road, the appendix (plan: actual situation) shows more detailed deficiencies at special locations.

2.4.1 Traffic safety

- bad consideration of non motorized traffic → increased risk of accidents

2.4.2 Motorized traffic

- high speed level because of generous dimensions for the motorized traffic (see figure 19) → increased risk of accidents for motorized and non-motorized road users
- almost no traffic lights → no reduction of speed to a safe and urban compatible level, no regulated traffic flow at highly strained junctions
- markings on the road meant to be a speed-reducing measure at junctions are ineffective (see figure 20)
- usability of right lane of the lower roadway partly reduced because of misuse for parking, vending etc.

figure 19: roadway with up to four lanes

figure 20: ineffective speed-reducing measures

2.4.3 Pedestrians

- parking on the sidewalk next to the lower roadway (see figure 21) → sidewalk cannot be used properly along parts of the examined stretch of the dyke road. Even though volumes of pedestrians walking along the road tend to be lower than their demand for crossings, a usable sidewalk has to be provided, if not mainly (but also) to improve walking comfort, in any case for traffic safety reasons.
- misuse of the sidewalk favoured by flattened curb (see figure 22)
- partly officially approved parking space on the sidewalk (see figure 23 and figure 24), leaving no space at all for pedestrians and forcing them to walk on the roadway
- often it is not even possible to evade to the bicycle lane (see figure 25)
- at some places bad surface of the sidewalk, reducing walking comfort
- no flattened curb at pedestrian crossings → problems for older and handicapped persons
- partly high curbs and deep gutters at intersections, leading to the usage of provisional steel ramps (see figure 27) and reducing walking comfort
- existing zebra crossings are not respected by the motorized traffic
- only little use of traffic lights to ensure safety at pedestrian crossing

- marked stripes for adapted speed reduction in front of crossings are ineffective
- parking, lingering, trading and waiting motorcycle taxi drivers on the sidewalk, parts of the bicycle lane and the right lane of the lower roadway worsen visibility of pedestrians at junctions
- partly too large turning radiuses at junctions and thus too high speed when turning → reduced safety for crossing pedestrians
- partly too long and thus unsafe zebra crossings passing up to four lanes
- extremely bad situation for crossing pedestrians at Long Bien due to unorganized traffic flow
- partly missing staircases or ramps at the central reservation in order to surmount height difference of adjacent roadways → uncomfortable climbing over railings (see figure 28 and figure 29)

figure 21: use of sidewalks as parking space

figure 22: flattened curbstones

figure 23: officially assigned parking space

figure 24: blockage of the entire side area by trucks

figure 25: obstructed sidewalk and bicycle lane

figure 26: bad surface of sidewalks on the western roadside

figure 27: steel ramps at pedestrian crossings

figure 28: uncomfortable climbing over the railing of the central reservation

figure 29: opening in the railing used for crossing

figure 30: makeshift staircase built by pedestrians

2.4.4 Cyclists

- oversized bicycle lane not corresponding to the demand (see figure 31)
- usability of bicycle lane is not given everywhere because of misuse (motorcycles, parking, delivery traffic, pedestrians, …) (see figure 32 to figure 34) → by pushing cyclists onto the roadway increased risk of accidents
- interrupted and thus unsafe guidance of cyclists at all intersections (priority of cyclists driving straight forward is not pointed out → see figure 35)
- missing direct links for cyclists at junctions in order to cross the central reservation, leading to illegal and dangerous traffic behaviour of cyclists driving in the wrong direction (see figure 36)
- endangerment of cyclists by busses in the area of bus stops at the curb, stopping on the bicycle lane (see fig. figure 37)
- missing bicycle installations at the most southern section of the dyke road on the eastern side of the road (see figure 38)
- partly low cycling comfort because of bad surfaces (see figure 39)
- no safe guidance across the roadway possible (see figure 40). Cyclists are facing the same problems as pedestrians when crossing the road, also at Long Bien despite special markings on the road for cyclists.
- at many places missing ramps for surmounting the height differences at the central reservation. Cyclists cannot even climb over the railing as pedestrians do.
- misuse of the ramps for cyclists by motorcycles

figure 31: oversized bicycle lane

figure 32: bicycle lane used for parking

figure 33: joint use of the bicycle lane by motorcycles

figure 34: bicycle traffic pushed onto the roadway

figure 35: interruption of the bicycle lane at the intersection

figure 36: bicycle traffic violating the driving direction due to missing links

figure 37: stopping of busses on the bicycle lane

figure 38: missing bicycle facilities along the most southern section of the dyke road (eastern side)

figure 39: bad surface quality of the bicycle lane

figure 40: disregard of crossing pedestrian and cyclist by motorized traffic

figure 41: misuse of bicycle ramps by motorcycle traffic

2.4.5 Public transport

- lack of bus stops at some important entrances to the dyke quarter (see also paragraph 2.1)→ long ways of walking to the bus stops, bad adjustment of catchment areas and thus insufficient accessibility of bus services for some parts of the dyke quarter
- partly no coordination of the locations of bus stops on opposite roadsides (see also paragraph 2.1) → travelling in both directions is unequally favoured at each entry to the dyke quarter
- bus passengers wanting to reach bus stops on the other side of the road face the same problems as pedestrians when crossing the road
- partly high frequentation of bus stops with more than one bus at a time is not sufficiently taken into account (see figure 42)
- partly bad accessibility of bus stops at the curb due to general misuse of sidewalks
- parts of the roadway have to be trespassed when boarding and alighting the bus (see figure 43)
- buses cannot be boarded and left on the level of the waiting area
- partly not enough space for waiting passengers at the bus stops and no bus shelters or other bus stop equipment on the eastern roadside (see figure 44 and figure 45)
- oscillating motions of busses between the left lane used by faster traffic and the bus stops on the right roadside → disturbance of traffic flow, increased risk of accidents, lower comfort of conveyance for bus passengers (uncomfortable lateral acceleration especially when standing)
- situation at Long Bien serving as a place for passenger transfers between busses cannot cope with its function → reorganisation of the area necessary

figure 42: high frequentation of bus stops by busses

figure 43: bus stops on the bicycle lane

figure 44: small sidewalk at the bus stop

figure 45: small waiting areas for passengers

2.4.6 General evaluation

After having described the deficiencies of the dyke road in detail, a general evaluation can be made by using the made up system of objectives from paragraph 2.2. This evaluation is shown in table 2. Cost-effectiveness is not assessed since the actual state of the dyke road does not induce any costs for construction.

object	objective		assessment criterion
traffic	traffic safety		gravity of accidents/accident rates
			speed behaviour of motorized traffic
	good quality of traffic flow	public transport	accessibility of bus stops
			quality of conveyance
		motorized traffic	quality of driving comfort
		cyclists	quality of driving comfort
			quality of crossing comfort
		pedestrians	quality of walking comfort
			quality of crossing comfort
	good coverage of the area		parking facilities
			quality of bus stops
precincts/environment	Low space consumption		traffic areas
	social serviceability		low functional separating effect
			amenity value
design of street space	Orientation		recognition of direction and distance
	animation and composition		creation of space, scale and proportions
cost-effectiveness	High cost-effectiveness		investment

table 2: general evaluation of the dyke road (green = good, yellow = medium, red = bad fulfilment of criterion)

3 Analysis of measures

3.1 General information

After the actual state of the dyke road has been described and the deficiencies have been identified, appropriate measures for a redesign of the dyke road can be identified. These measures must be adapted to the situation on-site and should preferably influence most or all of the given objectives within the system of objectives in a positive way.

This chapter presents the chosen measures in the following way: the characteristics of measures that are possible in general for improving different aspects will be described shortly. After giving such an overview, the respective measure chosen for the rearrangement of the dyke road will be specified along with a short

explanation why the chosen measure is considered to be favourable here. At the end, all chosen measures will be combined to a holistic redesign of the examined stretch of the dyke road, that can be seen in the appendix (plan: proposed concept), followed by a short assessment showing for all criteria in the system of objectives whether they have improved or not due to the new design. The presented concept for the dyke road respects the feedback to the draft report, which has been given by the Hanoi project partners. Moreover, the concept has been overworked after delivery of the draft report and feedback of the Hanoi project partners so that it differs sometimes mainly and sometimes partly from the exemplary drafts that have been presented for some of the intersections along the dyke road in the draft report.

The proposed design includes a plan for the rearrangement of the Long Bien intersection and the construction of a new Interchange Bus Stop at the Long Bien Bridge. Designs for this part follow a concept proposed by the project partners in Hanoi. However, some modifications are proposed offering the possibility for discussion. The design for the Long Bien Interchange Bus Stop also includes a Bike-and-Ride-Facility whose location, though not favourable in all aspects, has been adopted according to the request from the project partners in Hanoi.

The developed design includes no detailed construction plans. A design with exact measures for all elements cannot be delivered because of partly major differences between the provided available plans of the dyke road and its real construction as found in Hanoi.

3.2 Identification of possible measures

In the following paragraphs, the general elements that have been chosen for the new concept for the dyke road are derived. Remarks on particularities dealing with special situations at some points along the examined stretch are added directly in the appendix showing the proposed concept. At the end of this paragraph, cross-sections combining the previously described standard elements are shown, pointing out the complete partitioning of the available street space.

3.2.1 Motorized traffic

General Aspects

When dimensioning the space for motorized traffic on main roads it has to be taken into consideration that

- the standard design vehicle is in general the largest vehicle allowed according to the respective road traffic licensing regulations,
- the required space mainly depends on the predominant passing situation (in general passing of trucks) which is characterized by its frequency of occurrence, and
- the vehicle swept path is decisive for turning vehicles and especially for trucks and buses.

When choosing the dimensions of the carriageway it is of importance to determine whether some space is needed for other road user groups. The lane width also depends on the traffic volumes of buses and heavy vehicle traffic and the availability of space. The recommended standard lane width can be seen in table 3.

public transport (bus) and heavy traffic	space availability	
	high	low
high	3,50 m	3,25 m
medium	3,25 m	3,00 m
low	3,00	2,75 m

table 3: standard lane width

Proposed solution

For the dyke road and its high importance within the urban, regional and supra-regional network, it is crucial to provide at least two lanes for motorized traffic in each direction. However, motorized traffic should not be encouraged to exceed a speed limit of 50 km/h due to safety reasons for motorists, pedestrians and cylists. Therefore, a general lane width of 3.0 m has been chosen. On the eastern roadside, a wider lane width is not possible, at least not to the south of Chuong Duong Bridge, due to limited space availability, especially if a separated bus lane shall be provided (see paragraph 3.2.6). In the north of Chuong Duong Bridge, however, a lane width of 3.5 m is possible next to the proposed bus lane and has been chosen here. This can be also justified by the presumably higher traffic volumes on this section between Chuong Duong Bridge and Long Bien.

On the western roadway, a lane width exceeding 3.0 m would be possible along the whole stretch. However, here too, a maximum lane width of 3.0 m has been chosen. This lane width is a little bit smaller than shown in table 3, but this fact is considered to be beneficial for both directions of the dyke road. German guidelines are for roads that are mainly used by cars whereas the most used vehicle in Hanoi is the motorcycle with much smaller space consumption. Therefore, the given lane width is considered to be sufficient and is moreover appropriate to encourage road users to respect the speed limit, which is very favourable for crossing non-motorized road users. Trucks mainly use the road at night time since they are not allowed during the day. Therefore, no conflicts between motorcyclists and trucks must be feared.

Another effect provoked by the sufficiently provided but reduced roadway is assumed: since there is less space for motorists, they have to drive more carefully and traffic is denser. This will most likely prevent the oscillating driving style of bus drivers switching from the right to the left lane and back again at the next bus stop (see also paragraph 3.2.6). The gain of speed on the left lane will be much smaller due to the new design, and changing lanes will be less favourable for them. On the western roadside, where no exclusive bus lane is provided in the proposed design, this effect must be considered to be beneficial.

All in all, two lanes for motorized traffic are provided on the eastern roadway and three lanes on the western roadway. The right lane on the western roadway partly becomes a non-exclusive bus lane at bus stops, allowing bus drivers to approach bus stops more easily. The number and width of lane will be able to handle actual traffic volumes and, in addition, is also adapted to a possible decrease of traffic volumes after the construction of additional bridges over the Red River, relieving the traffic situation on the examined stretch of the dyke road.

The shown redesign in the appendix (plan: proposed concept) respects the swept path of buses and trucks.

3.2.2 Bicycle facilities

General aspects

General options for guiding cyclists along main roads are

- on the carriageway or in the side area,
- on separate areas or on areas that can also be used by other road user groups,
- on one or both sides of the road, and
- in one or two directions.

It can be appropriate to use different types of bicycle guidance along road sections and at junctions.

The option for guiding **Bicycle traffic on the carriageway** is advisable if

- the speed of motorized traffic is compatible to cycling on the road,
- cycling is a common mode for the respective city that road users are used to, and
- motorized traffic can be handled on two lanes due to surplus capacity on four lane roads.

However, four lane roads with or without public transport are in general inappropriate for bicycle guidance on the carriageway.

figure 46: bicycle traffic on the carriageway

Bicycle lanes are on the same level as the carriageway and separated from it by a parallel marking on the floor or a parking lane. Different types are (see also figure 47):

- bicycle lanes without adjacent parking lane,
- bicycle lanes between traffic lanes and parking lanes, and
- bicycle lanes between parking lanes and the side area.

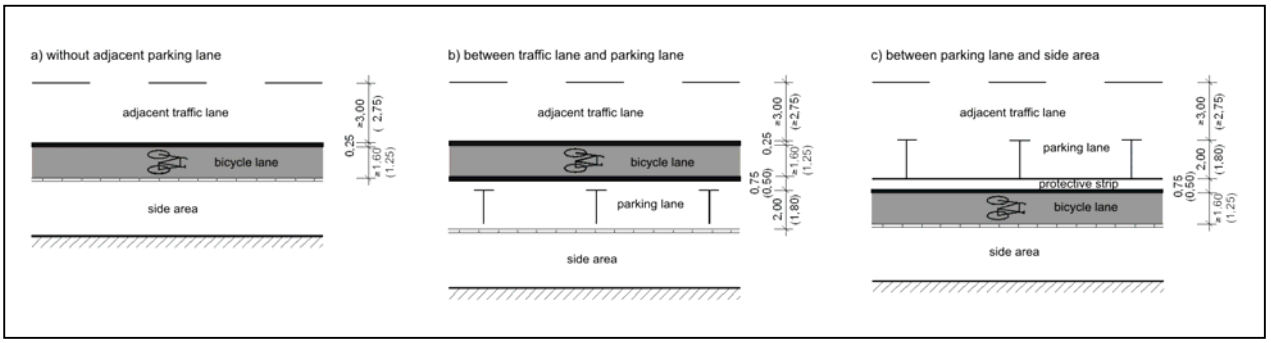


figure 47: dimensions of bicycle lanes and adjacent areas

Advantages of bicycle lanes are

- a good visibility of cyclists for motorists and vice versa,
- a reduced probability of usage against mandatory driving direction,
- a driving comfort comparable to the one of motorists, and
- a good quality for lingering in the side area due to more space for pedestrians and thus few disturbances.

Disadvantages are:

- low separation of cyclists and faster motorized traffic and
- danger by opening vehicle doors when used next to an adjacent parking lane.


figure 48: bicycle lanes

Separated bicycle paths along the road are separated from the carriageway by a marginal strip or a protective strip. They can be carried out as bicycle paths that can be clearly differentiated from the sidewalk area for pedestrians, or they can be marked on the unvaried side area.

Its advantages are:

- the almost complete separation from both motorized traffic and parking lanes along road sections,
- the possibility to reduce the width of the bicycle path at some points with unfavourable constraints, where otherwise bicycle facilities would not be possible at all, and
- the possibility of bidirectional bicycle paths along wide multiple-lane roads with high intensity of usage on both sides of the road in order to avoid dangerous crossings.

Its disadvantages are:

- missing eye contact between motorists and cyclists, and
- possible conflicts between cyclists and pedestrians at sections with narrow side areas.

If both sides of the road are flanked by buildings, bicycle paths should be implemented on both sides, too. By offering sufficient crossing possibilities, the usage of bicycle paths in the wrong direction should be reduced.

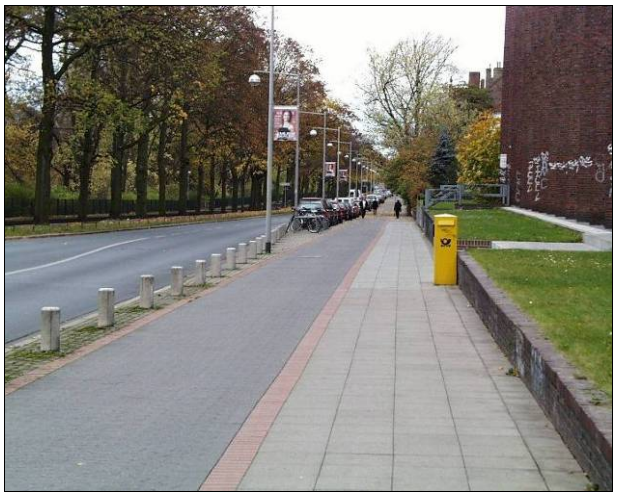



figure 49: bicycle path along the road

Guidance of cyclists on **combined sidewalk and bicycle paths** can be considered if

- volumes of cyclists and pedestrians are low and a mutual endangerment is thus not given, and
- guidance of cyclists on the carriageway would be too dangerous while there is no space for other cycling facilities.

usable width of sidewalk	Σ cyclists and pedestrians	thereof pedestrians
> 2.5 – 3.0 m	70	≥ 40
> 3.0 – 4.0 m	100	≥ 60
> 4.0 m	150	≥ 200

table 4: minimum width of combined sidewalk and bicycle path for different pedestrian and cyclist volumes per hour

figure 50: combined sidewalk and bicycle path

Proposed solution

Along the dyke road, cyclists should be separated physically from the individual motorized traffic due to safety reasons. A physical separation also reduces the risk of misusage by motorcyclists. On the eastern roadway, a bicycle lane of 2.0 m is proposed that is physically separated from the individual motorized traffic by a bus lane (see paragraph 3.2.6). To the north of Chuong Duong Bridge, the width has been increased to 2.5 m due to less space constraints. Since the bus lane switches to the other side of the carriageway on this section and its protective effect is thus no longer given, a small physical barrier between the bicycle lane and the adjacent lane for motorized traffic is proposed here. The separated bicycle lane along the eastern roadway guarantees a high driving comfort for cyclists plus an increase of safety.

Along the most southern section of the eastern roadway, there is not enough space for cycling facilities next to the two lanes of motorized traffic. A bicycle lane, which is *not* physically separated from the motorized traffic, is inappropriate along the dyke road because it is not safe enough and the risk of misusage is high. Therefore, guidance of cyclists on a mixed area (cyclists, pedestrians, motorcycles) *behind* the dyke wall is proposed as the most appropriate solution here. However, along the rest of the dyke road, where more space is available, the described bicycle lane is the preferred solution.

Along the western roadway, a separated bicycle path with a width of 2.0 m has been chosen to be appropriate. It is separated from the roadway by a parking lane and a protective strip or a green strip and is thus safe and the risk of misusage by driving and parking vehicles is low. According to the request of Hanoi project partners, it is on the same level as the roadway and thus separated from the sidewalk by a curb. This shall reduce conflicts between pedestrians and cyclists using the same side area. However, separated bicycle paths in the side area are usually on the same level as the sidewalk in Germany. This might be a problem in Hanoi since it is not unlikely that the bicycle path might also be used by pedestrians, shops and other service providers in this case. If this risk is not seen by Hanoi project partners, the bicycle path could also be carried out on the same level as the sidewalk.

Both cycling facilities along the eastern and western roadway are meant to be used in one direction only. Due to its generous width of 2.0 m and 2.5 m respectively, especially the segregated bicycle path along the western roadway can also be used in two directions if necessary. This might be useful along some stretches of the dyke road with intensive use of the side area, and especially along the most southern section where bicycle facilities on the eastern roadway cannot be provided due to lack of space. However, usage in both directions may not necessarily be allowed. The series of T-junctions that are partly close to each other are unfavourable for such an allowance. It is thus an option that can be considered, but its advantage and disadvantage must be weighed up.

On the western roadway, the bicycle path can be led behind bus stops without having to deviate it (see also paragraph 3.2.6). At bus stops on the eastern roadway, the bicycle lane next to the bus lane should be led behind the bus stop and its waiting area. This allows the bus driver to stop at the curb of the waiting area without having to turn sideward, and cyclists can pass the bus stop safely behind the waiting area even when a bus is present.

All T-junctions along the western roadway should be equipped with a road surface raised to the level of the sidewalk in the subordinated street (see also paragraph 3.2.4). This increases the motorist's awareness for crossing cyclists.

3.2.3 Sidewalks

General aspects

Sidewalks are indispensable along all main roads. They should not be smaller than 2.5 m, while larger dimensions are required according to the usage of the side area.

figure 51: sidewalks

Proposed solution

The actual course of the curb has not been changed in the proposed designs. This was done also due to economic reasons. The drainage system of the street in general follows this curb. Touching the drainage system would cause high costs that are moreover not necessary in this case. The width of the western

sidewalk is considered to be wide enough to serve the demand of walking. Furthermore, the demand of walking along the dyke road was said to be rather low compared to the demand of crossing. The only problem is thus to keep the existing sidewalk clear from other usages in order to provide a good walking comfort. Since the new design of the dyke road provides a parking lane, this will help to keep parking motorcycles and vehicles away from the sidewalk and thus improves the usability of the sidewalk. The usage of the sidewalk for vending and other service cannot be prevented, but a moderate usage for these purposes is not considered to be an important problem.

The sidewalk along the eastern roadway is smaller. But at this side of the road there is no need to provide vast walking facilities. Appropriate crossings will be offered at each entry to the dyke road (see also paragraph 3.2.4) and pedestrians can either cross the street first and then walk along on the sidewalk of the western roadway, or they can walk behind the dyke wall. Sidewalks along the road's side of the dyke wall are thus only necessary to reach the bus stops which are always very close to the entrances of the dyke quarter.

An improvement of the partly heavily damaged surface of the sidewalk at various places is advisable.

3.2.4 Road crossings

General aspects

Crossing supportive measures are

- extended side areas,
- narrowing of the traffic lanes,
- central reservations, and
- traffic islands.

Crossing supportive measures do not induce priority for cyclists, pedestrians and disabled persons. However, they facilitate safe crossing of considerably wide carriageways where high traffic volumes occur. If well designed, they highlight the locations where motorists have to reckon on crossing pedestrians and cyclists. In general, crossing supportive measures do not influence traffic flow in a negative way.

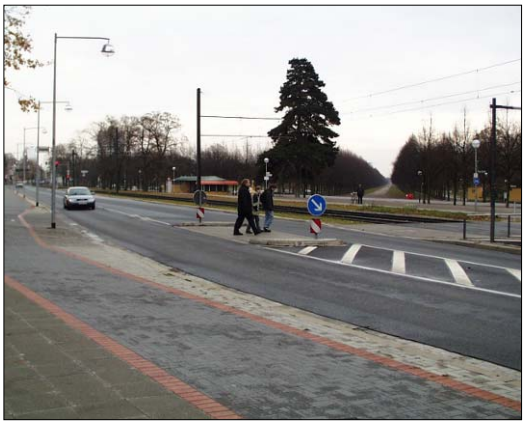


figure 52: traffic island

figure 53: extended side areas

Zebra crossings are appropriate crossing facilities if they are used often and systematically and thus are common elements within a city and not just seen at singular locations. The combination of zebra crossings and traffic islands is especially favourable, because

- the carriageway can be crossed in two steps,
- overtaking is impeded, and

- they are clearly visible.

figure 54: zebra crossing

Pedestrian crossings at **traffic lights** are notably safe for cyclists, pedestrians and handicapped persons, whereas the increased waiting time for pedestrians and cyclists compared to other crossing facilities is disadvantageous. If the waiting time is too long, the portion of pedestrians walking during the red phase increases noticeably. At junctions with traffic lights, traffic islands as a supportive measure are appropriate.

Overpasses and underpasses are reluctantly used in Germany within cities. They have been a favoured design element of the 1960s when planers tried to separate different user groups physically. However, this approach turned out to be ineffective in many cases, since pedestrians are very sensitive when it comes to detours. They prefer crossing the street on the same level, even if over- or underpasses are provided. Especially underpasses are often dark and tend to become dirty quickly.

Over- and underpasses are a measure that should be used according to the local topography. Roads in a fosse are favourable for overpasses, since pedestrians mainly stay on the same level. Underpasses are appropriate for roads on a bank. Here too, pedestrians do not have to surmount different height levels. They are equally useful to allow the crossing of roads that are exclusively for fast motorized traffic. Both over- and underpasses must be considered to be rather expensive measures. And they induce huge space consumption for flat ramps that should be provided for cyclists and handicapped persons.

The range of use for choosing different forms of crossing facilities depends on

- the type and frequency of crossing traffic,
- the desired quality of traffic flow for motorists and pedestrians,
- the length of the crossing,
- the necessity or desirability of safe crossings,
- the common form of crossing within the city,
- the overall appearance of the street space and its influence on driving behaviour.

Proposed solution

A safe crossing for pedestrians and cyclists is one of the main concerns along the dyke road. Given the volumes of the motorized traffic and the observed unsafe behaviour that non-motorized road users are forced to when crossing the road, the best choice in order to increase safety along the road are traffic lights. Therefore, and according to the feedback of the project partners in Hanoi, the proposed redesign of the dyke road includes traffic light controlled junctions at each entry to the dyke road. This must be considered to be the only useful measure to improve the situation and safety of crossing non-motorized road users substantially. And traffic lights at these locations are conform to the high importance of these places for pedestrians entering and leaving the dyke quarter, as the traffic counts show. Another advantage of this solution is that the sometimes confused and unordered traffic flow at some junctions can be prevented.

While traffic lights improve comfort for pedestrians, they also decrease driving comfort for motorists along the dyke road. But the increase of safety also positively affects motorists. And since the two driving directions along the dyke road are handled on separate, independent roadways and there are thus no dependencies that have to be respected, the implementation of a progressive signal system improving driving comfort is rather easy.

The pedestrian crossings at traffic lights are located preferably close to the centre of the junction in order to avoid detours. They cover all passages and directions that pedestrians might want to walk to, because otherwise the risk of pedestrians crossing the street at places other than the provided crossings at traffic lights increases if some directions of importance are not covered. All controlled crossings provide a width of 4.0 m for pedestrians and of 2.0 m for cyclists.

As the counts of pedestrians leaving and entering the dyke road show, locations with stairs surmounting the dyke wall along road sections must not be neglected since they are also of importance for pedestrians, even though the total crossing demand tends to be a little bit lower. At these locations, a combination of traffic islands and zebra crossings is proposed on the western roadway. Traffic islands are favourable to allow pedestrians to cross the road in two parts while reducing speed of motorized traffic at the same time. To highlight the crossing and to make it clearly visible, an additional zebra crossing has been added at each of these crossings. The actual situation shows that zebra crossings as a stand-alone measure are rather ineffective. Therefore, it would be desirable to use the same combination of traffic islands and zebra crossings also on the eastern roadway. However, there is no sufficient space to include traffic islands between the two lanes for motorized traffic. Therefore, zebra crossings are proposed despite their disadvantage of being rather neglected. It is at least beneficial that only two lanes have to be crossed by pedestrians. The included crossing of the bus lane and the bicycle lane is not considered to be critical. Traffic lights are not proposed along sections in order not to further decrease driving comfort for motorized traffic.

At all T-junctions along the western roadway, the level of the road surface is raised by 10 cm (or to the level of the sidewalk respectively) in the subordinate street via ramps and coloured in red in order to increase awareness of the conflict situation and to adapt driving behaviour. This prevents inattentive turning movements jeopardizing other road users, especially pedestrians and cyclists.

Over- and underpasses are not considered to be an appropriate measure due to their disadvantages that have already been sketched in the general description. The topography of the road that is neither in a fosse nor on a high bank forces pedestrians and cyclists to surmount an important difference of walking level if they have to use an over- or underpass. It is very likely, that they will cross the carriageway directly instead of using over- or underpasses inducing inclination on the ramps. Furthermore, the ramps must be very long in order to be usable for cyclists and are thus very space consumptive. Overpasses will cause conflicts with the high-voltage power line that can be found along the central reservation. Underpasses are not considered in order to avoid perforating the dyke and, again, also due to the long, space consumptive ramps forcing pedestrians to detours. Furthermore, overpasses and underpasses are regarded as too expensive.

3.2.5 Parking

General aspects

Necessary parking space can be included

- on the carriageway,
- in parking bays,
- in the side area, or
- on wide central reservations.

The following orientations for parking space are possible:

- parallel parking,
- perpendicular parking, or
- angle parking.

figure 55: parallel parking

figure 56: angle parking

figure 57: perpendicular parking

At main roads all orientations are applicable. When choosing the orientation and position of parking space, it is of importance

- how much space within the whole street space is available for parking,
- whether the traffic volumes and the classification of the main road allow the usage of the opposite traffic lane when driving into a parking space or pulling out,
- whether the offered parking space shall be concentrated at a special location, and
- whether the desired appearance of the street space suggests a certain orientation.

Along highly used main roads with traffic light controlled junctions it is of special importance to note that the orientation and positioning of parking space shall be compatible to the desired steady traffic flow. It is favourable

- to ensure quick and easy parking,
- not to place parking space right behind a junction, and
- to use appropriate dimensions for parking space.

table 5 shows current dimensions for different orientations.

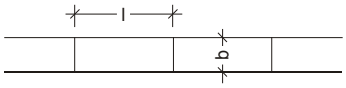
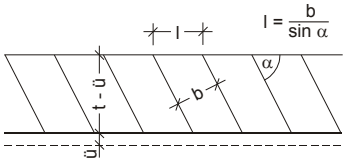
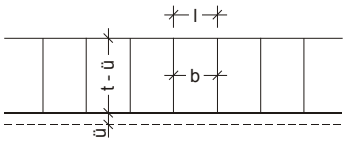
	angle α [gon]	depth from curb t – ü [m]	width of strip for car over-hang ü [m]	width of parking bay b [m]	length of parking bay l [m]		width of access road g [m]	
					parking		parking	
					forward	backward	forward	backward
parallel parking 	0			2.00	6.70	5.70	3.25	3.50
angle parking 	50	4.15	0.70	2.50	3.54		3.00	
	60	4.45	0.70	2.50	3.09		3.50	
	70	4.60	0.70	2.50	2.81		4.00	
	80	4.65	0.70	2.50	2.63		4.50	
	90	4.55	0.70	2.50	2.53		5.25	
perpendicular parking 	100	4.30	0.70	2.50	2.50	2.50	6.00	4.50

table 5: dimensions of different parking facilities

Proposed solution

As the observations showed, there is a high demand for parking along the western carriageway of the dyke road. The central reservation is already used for parking and has not been touched by the redesign so far, except for the bus terminus at the southern section where a rearrangement is proposed (see paragraph 3.2.6). In order to relieve the parking situation along the western roadside, a parking lane with a width of 2.50 m is provided, accompanied by a protective strip of 0.5 m separating it from the bicycle path and protecting cyclists from opening car doors. The chosen width of the parking lane is 0.5 m wider then required according to the German guidelines. This was done in order to allow comfortable and quick

parking without disturbing the traffic flow more than necessary. The parking lane is interrupted close to junctions, at bus stops and at other inappropriate places, where it turns into a green strip. The parking lane can be used by cars for parallel parking or by motorcyclists for angle parking. Thus, the misusage of the sidewalk for parking should be reduced, which increases walking comfort. Officially assigned parking space on the sidewalk along the southern section can also be avoided by this proposition.

3.2.6 Public transport

General aspects

Guidance of public transport along main roads is possible on special bus lanes as well as on the carriageway. Bus lanes can be reserved temporarily or the whole day. They are located either in the middle of the road or at the side. Their purpose is to:

- minimize and avoid disturbances of motorized traffic,
- to reduce travel time of public transport,
- to assure regularity and punctuality, and
- to highlight the importance of public transport within a city.

Along road sections it is possible to use

- entire or partial bus lanes (special separation), and/or
- temporal separation of different modes.

Entire bus lanes along the whole sections are preferably appropriate

- to assure regularity and punctuality,
- to highlight the importance of public transport within a city,
- if buses run with a high frequency, and
- if there is enough space left for other user groups.

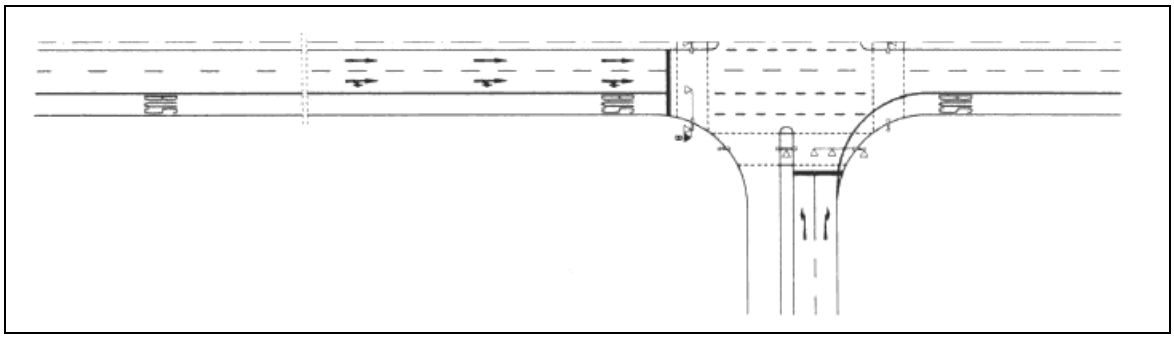


figure 58: whole-time bus lane on the side of the road

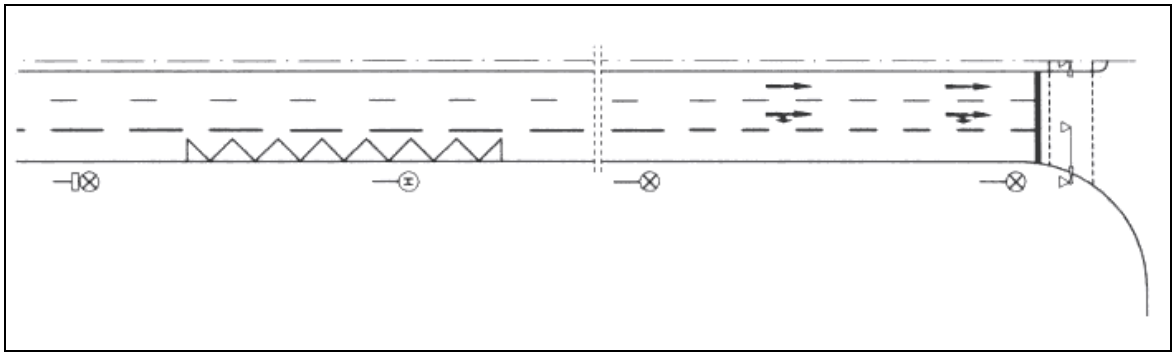


figure 59: temporary bus lane on the side of the road

The positioning and layout of **bus stops** mainly influence attractiveness of public transport. It is thus important that they

- allow passengers to reach it safely, comfortably and fast from all directions,
- allow comfortable waiting,
- minimize the duration of stops,
- allow the boarding of buses for handicapped persons in an appropriate way, and
- highlight the presence of public transport in the street space.

Bus stops can be built in the middle or at the side of the road. Bus stops on the side can be reached safely, fast and directly. It is advisable to use extended side areas serving as waiting space and minimizing conflicts with cyclists and pedestrians in the side area. If bus stops are located in the middle of the road, passengers have to cross the carriageway to reach and leave it. This might reduce traffic safety according to the circumstances. Safe crossings have to be provided in any case.

If bus stops are at the side of the road, buses can stop

- on the carriageway,
- at the curbstone of the extended side area, or
- in a bus bay.

The advantage of bus stops on the carriageway is that they can be implemented without important constructional measures and located at any place. However, obstruction due to parking vehicles is likely, and stopping buses disturb the traffic flow.

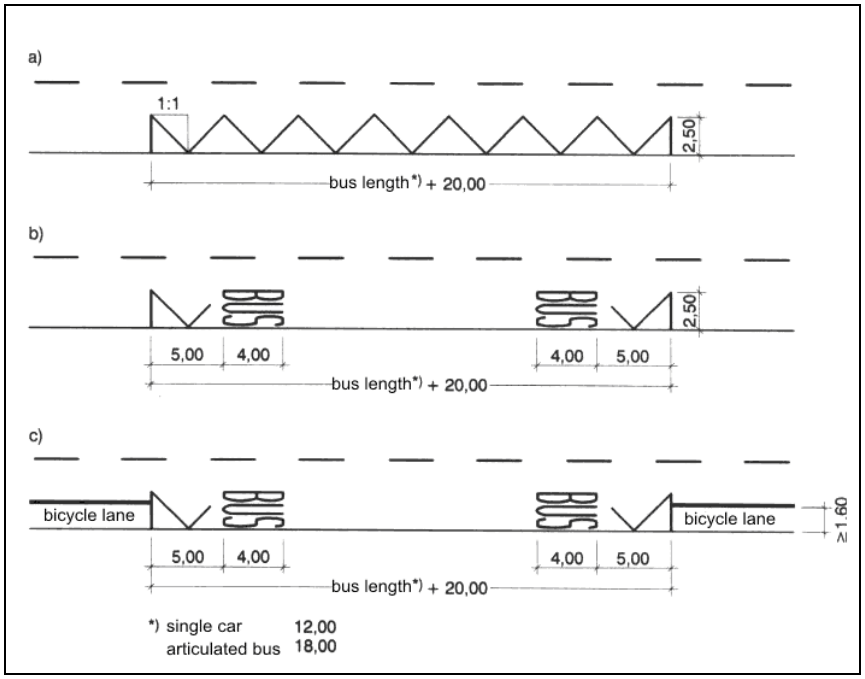


figure 60: different markings for bus stops on the carriageway

Bus stops with an extended side area are more favourable, because they

- allow straight driving of the bus at the bus stop parallel to the curb and are thus shorter,
- minimize the risk of obstruction due to parking vehicles, and
- provide a vast waiting space without causing conflicts with separately guided bicycle paths in the side area.

Because of its dominating advantages this type of bus stop should be used often and regularly along mains roads.

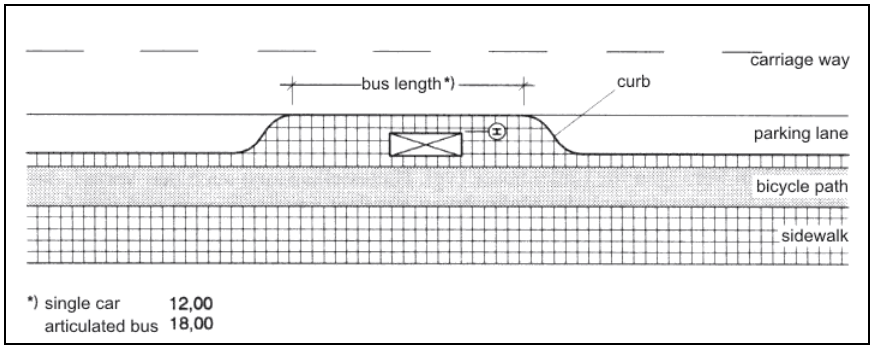


figure 61: dimensions of bus stops with extended side areas

Proposed solution

Since many bus routes serve the examined corridor, a preferably undisturbed guidance of buses should be aimed at. On the eastern roadside, enough space is available to implement a reserved bus lane with a width of 3.0 m on the right side. It should be separated from the two lanes for motorized traffic by a small barrier between the lanes in order to avoid misusage. This barrier and the bus lane itself also protect the adjacent bicycle lane (see paragraph 3.2.2). A separation between bus lane and bicycle lane is not necessary. The bus lane on the right side benefits bus stops on the roadside which are more comfortable for passengers than bus stops in the middle of the road since the former can be reached directly from at least one side of the road.

The Duong Chuong Bridge is sort of a break separating two different sections of the dyke road. Since the Interchange Bus Stop at Long Bien at the end of the northern section is located in the middle of the road, the bus lane along this section has been switched to the left lane in order to allow buses to enter the Interchange Bus Stop more easily. A lane width of 3.5 m for buses can be provided here. The positioning of the bus lane on the left side of the carriageway induces that one bus stop right to the north of Chuong Duong Bridge has to be built on a traffic island in the middle of the road. This sort of bus stop is possible and provides enough waiting space with a width of 3.0 m if the bus lane is reduced to 3.0 m again and the width of adjacent lanes for motorized traffic to 2.75 m. But the road has to be crossed by passengers coming from its both sides in order to reach the bus stop. However, this can be tolerated, given the fact that this solution provides a better accessibility of the Interchange Bus Stop for arriving buses.

On the western roadway, bus stops should also preferably be on the side of the road rather than in the middle in order to provide direct access for passengers. However, a bus lane on the right side cannot be implemented along this roadway since the usage of the side area is various and especially the parking lane must be accessible for all sorts of motorized traffic. Therefore, no special bus lane is provided to the south of Duong Chuong Bridge, but a partial, non-exclusive bus lane at bus stops that will also be separated from the rest of the road by a small physical barrier. But since the lane width for motorized traffic is reduced to 3.0 m (see paragraph 3.2.1) and thus the speed on the dyke road is supposed to decrease to a safe level and traffic becomes denser, it is assumed that bus drivers will no longer tend to drive on the left lane and then return to the right lane at bus stops because no gain of speed will be achieved anymore. Furthermore, such an oscillating driving style will not be as favourable as at present since bus stops get much closer after rearrangement of the dyke road and bus drivers would be forced to return to the right lane right after they just reached the left lane. And they would have to reach the right lane some distance *before* they arrive at the bus stop because they have to approach on the partial, non-exclusive bus lane at bus stops which can only be accessed at its beginning due to the small physical barrier.

To the north of Chuong Duong Bridge, the same solution providing a bus lane on the left side of the roadway is proposed due to the same reasons as for the eastern roadway. It is compatible to the

Interchange Bus Stop that is left by buses on the left side of the roadway. Such a bus lane induces another bus stop in the middle of the road, opposite to the according bus stop for the other direction, but this can be tolerated, too, as has already been argued for.

As the observations have shown, the present locations of bus stops are unsystematic and unfavourable. To provide a good accessibility of public transport, distances between bus stops should not exceed 400 to 500 m. In accordance with the project partners in Hanoi, the improved bus stop locations as shown in figure 62 have been chosen. A bus stop for both directions at each entrance to the dyke road is provided. At these locations, bus passengers can use the same crossing facilities as other pedestrians and cyclists. A safe crossing is thus guaranteed.

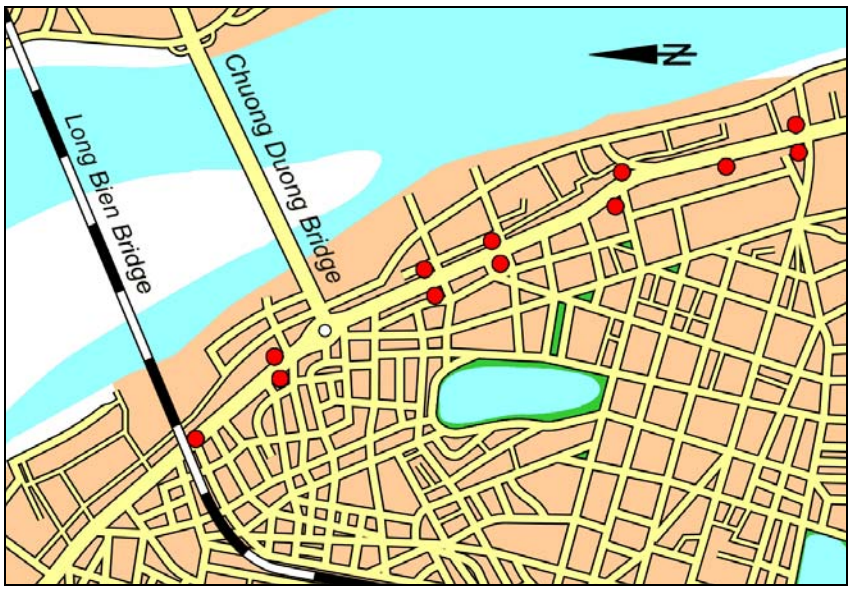


figure 62: proposed locations of bus stops

Since the most favourable design for bus stops is the one using extended side areas, this type of bus stop has mainly been chosen for the corridor. It allows good accessibility for both bus drivers and passengers and can be easily integrated into the side area by interrupting the parking lane along the western roadway in order to provide sufficient waiting space. This can be done at the proposed locations, but also at any other position the project partners in Hanoi might judge to be more favourable. This type of bus stop thus guarantees a certain flexibility. Guidance of cyclists can be uninterrupted behind the waiting space. On the eastern roadway, this type of bus stop can be used as well by deviating the bicycle lane to the dyke wall, using the gained space as waiting space instead. The bicycle lane will be raised to the same level as the waiting space via small ramps.

Bus bays have not been chosen since they are not well accessible for bus drivers, come along with a reduced comfort of conveyance for passengers due to lateral acceleration and consume a lot more space than any other type of bus stop.

For the chosen type of bus stops where buses can drive straight, the length needed to allow two buses at one time to stop is 25.0 m. In order to allow easy boarding and alighting of passengers, the height of the waiting space must be adapted to the used type of buses. However, the proposed concept does not constrain the possible height of the waiting space. If it is higher than approximately 20 cm, small steps should be considered, as well as small ramps.

Due to the chosen position of bus lanes along the northern section, one bus stop in each direction had to be positioned in the middle of the road, as has already been pointed out. The chosen bus stops are as easily accessible for buses as those at one side of the road. A tolerated disadvantage is the fact that passengers have to cross the roadway in order to reach the bus stop, no matter from which side of the road they are coming. But safe crossings are offered according to the proposed design.

The terminus bus stop in the south on the central reservation has been adapted in order to decrease disturbances of traffic flow caused by buses that are about to pull in or to pull out. Boarding and alighting of buses has been facilitated for passengers by assigning special locations for this purpose. This improves their orientation.

3.2.7 Transfer and terminal bus stations

General aspects

Transfer and/or terminal bus stations should be located outside of the general traffic areas in order to avoid disturbances of the individual motorized traffic. They must dispose of high-capacity connections to the urban road network. The following principles have to be taken into consideration:

- roads leading to and coming from the terminal station should preferably provide bus lanes in order to guarantee an undisturbed approach of buses, and
- high-capacity entries and exits should be provided respecting the driving geometry of buses.

When designing transfer and terminal bus stations, it is advantageous to assign defined departure positions to each bus line in order to facilitate the passenger's orientation. Safe and comfortable transfers with short walking distances and a low expenditure of time should be promoted. The different departure positions should therefore be as close together as possible. The ways for transfers should be lead in such a way that only few conflicts with driving buses occur. In any case, enough space should be provided two allow buses to pass stopped buses waiting at their departure position.

When transfer and terminal bus stations are located in the middle of the road between the carriageways for both directions, a safe accessibility for passengers is especially crucial. In this context, at-grade crossing should always be implemented as zebra crossings or crossings at traffic lights.

The unwanted important length of departure positions arranged in a row can be reduced by turning them into a slight angle, facilitating an independent approaching and leaving of each position. The general dimensions of such an arrangement can be seen in figure 63 and figure 64. Y, F and A are values depending on each other.

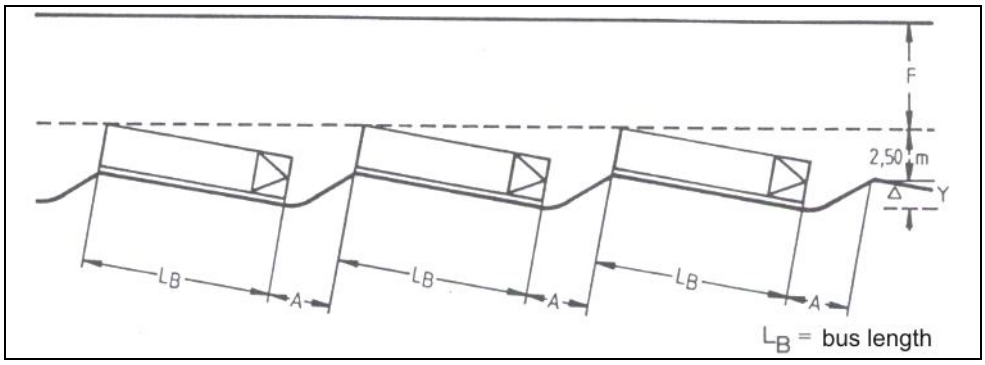
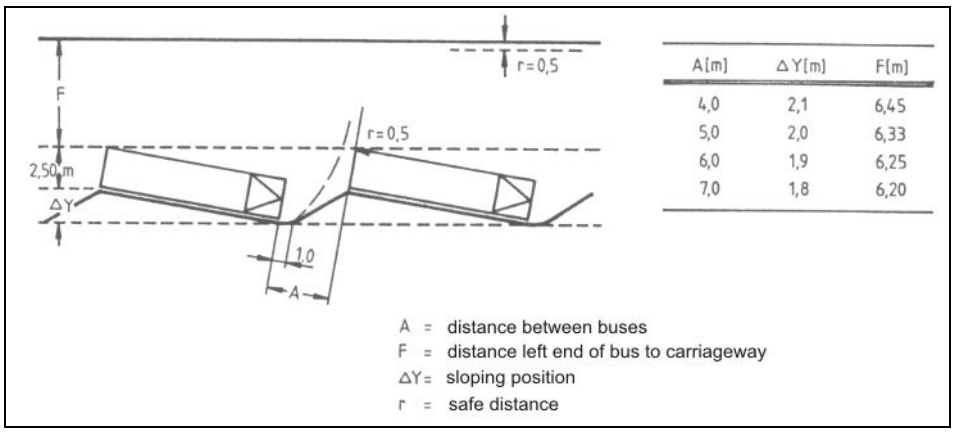


figure 63: independent departure positions arranged in an angle



A[m]	ΔY[m]	F[m]
4,0	2,1	6,45
5,0	2,0	6,33
6,0	1,9	6,25
7,0	1,8	6,20

figure 64: dimensions of independent departure positions

Proposed solution

Due to the given location of the Interchange Bus Stop at the Long Bien Bridge between the two carriageways and the resulting restrictions of available space, the described arrangement of departure positions in a slight angle has been chosen. This allows including the highest number of independently reachable departure positions. The chosen width of the bus carriageway allows passing stopped buses.

The Interchange Bus Stop can be approached and left safely and comfortably by buses. The distances for transferring passengers are short and the station at Long Bien Bridge is also within reach. The Interchange Bus Stop can be reached safely by pedestrians from all directions.

3.2.8 Bike-and-Ride-facility

General aspects

At bus stops of high importance and/or those benefiting from large bicycle catchment areas, a sufficient number of Bike-and-Ride parking positions for bicycles should be provided in order to promote this means of transportation as a feeder to the public transport system. These facilities should be located preferably close to the bus stop and be safely accessible from the bicycle lanes and paths leading to the bus stop. They should be equipped with a roof and allow safe attachment of the bicycle to protect it against theft. The latter can be realized by providing bent metal bars with a length of approximately 1.5 m and a height of approximately 55 cm. These bars equally support comfortable leaning of the bike against the bar. The distance between these metal bars should be at 1.5 m in order to allow comfortable parking. Two bicycles can be attached at one bar, one on each side of it. Bicycle stands that only fix the front wheel easily damage the bicycles and do not offer the possibility for good protection against theft.

In front of the parking positions, a certain area for moving the bicycles is needed. Its width depends on the angle that the parking bicycles are oriented at.

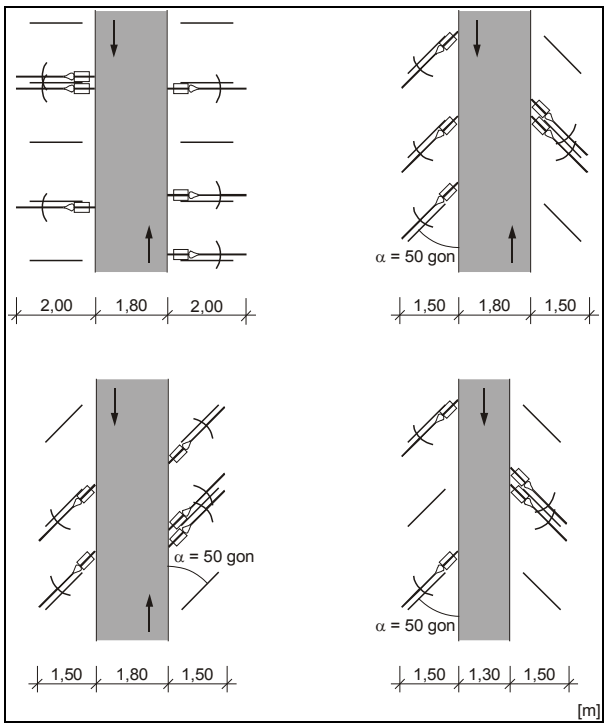


figure 65: dimensions of parking positions for bicycles

Parking positions for motorcycles are not equipped with such a metal bar but are plain areas that have to be kept clear. The distance between two motorcycles should be at approximately 1.5 m for perpendicular parking and at approximately 1.1 m for angle parking.

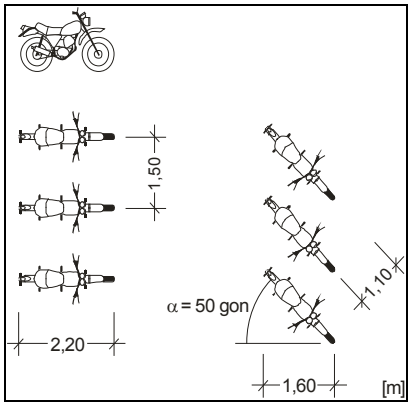


figure 66: dimensions of parking positions for motorcycles

Proposed solution

The location of the Bike-and-Ride-facility has been chosen by the partners in Hanoi to be to the south of the bus platforms. The design standard and the dimensions of the at-grade Bike-and-Ride-facility are based on German guidelines. For a better traffic flow and for high traffic safety the facilities for motorcycles and bikes are separated. Both facilities are located close to the bus stop and are safely accessible from the street and the bicycle lanes. Sidewalks lead to the bus terminal. Perpendicular parking was chosen for motorcycles and bikes. All carriageways could be used in two directions. The proposed solution will provide space for a total of about 200 motorcycles and about 200 bicycles.

3.2.9 Cross-sections

The general cross-sections that result from the previously described chosen elements can be seen in figure 67 and figure 68.

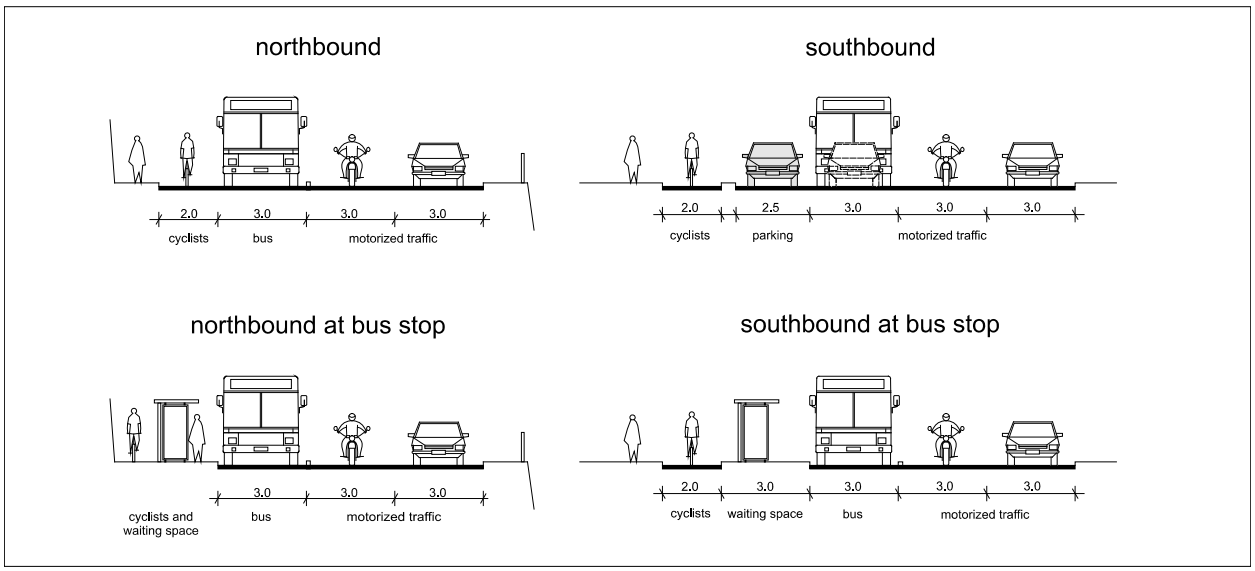


figure 67: general cross-sections along the road stretch to the south of Chuong Duong Bridge

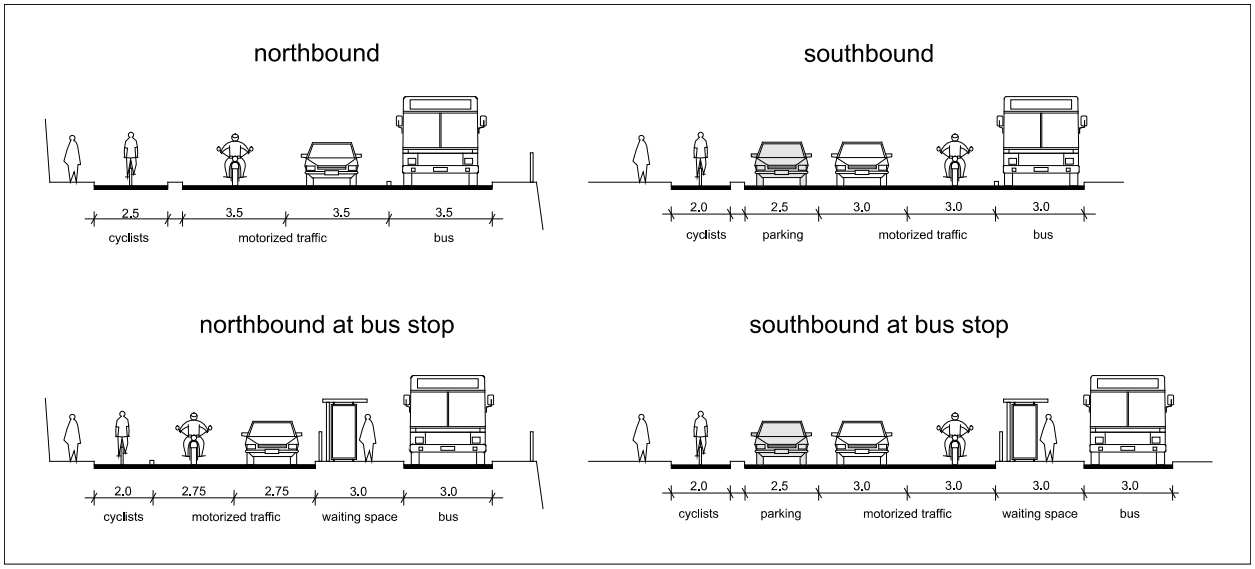


figure 68: general cross-sections along the road stretch to the north of Chuong Duong Bridge

3.3 Assessment of the impact and appraisal

After all chosen design elements have been derived and described and the new concept for the dyke road has been presented in the previous paragraphs and in the appendix, a short assessment of the impact of the rearrangement will be done by using the system of objectives. This gives a short overview of the achieved improvement.

Within the first object "**traffc**", traffic safety has definitely improved. The new and secured crossing facilities at all major junctions increase safety for non-motorized road users, and due to the reduced number and width of lanes, the speed behaviour of motorists can be positively influenced.

The accessibility of bus stops has been improved significantly for both bus drivers due to the chosen type of bus stops as well as for passengers due to additional bus stops and good crossing facilities. The driving comfort of motorcyclists is judged to be unchanged, compared to the present state, but this objective has not been considered to be of high importance. The provided number of traffic lanes is considered to be still sufficient to deal with the traffic volumes. For both cyclists and pedestrians, the very important driving and walking comfort has improved, especially concerning their possibilities to cross the

road. Traffic along the road has also improved for these modes. However, the improved crossings are dominating the achieved improvement.

The formerly strained parking situation at the dyke road could be relieved by providing a parking lane that offers official parking space at many places where no parking was allowed before. However, the demand for parking is high along the western roadway and there might still by some lack of parking space that could not be sufficiently addressed.

The quality of bus stops has mainly improved. More bus stops are provided and they offer shelter at rain and sufficient and comfortable waiting space. By adapting the height of the waiting space, boarding and alighting can be facilitated.

Concerning "**precincts and environment**", the space consumption of the road has not changed significantly, but has not been considered to be of high importance. The separating effect of the dyke road, however, could be reduced. Nevertheless, the dominating character of the road cannot be eliminated completely, especially since one carriageway is built on the dyke and accompanied by a protective wall. Due to the new design with a green strip at places where the parking lane is interrupted, a slight increase of the amenity value might be justifiable, but this criterion was not considered to be of high importance anyway.

The orientation along the road, first of two objectives within the field of "**design of street space**", has not changed but had already been judged to be good at present. Due to the new partitioning of the street space, a slightly better animation and composition of the road can be assumed, but was not judged to be of importance.

The improvement of "**cost-effectiveness**" cannot be derived, since no costs occur for the present state of the road. However, as has already been highlighted, the chosen measures are rather economic. The curb of the road has not been touched, which would have induced high costs. Expensive (and most likely ineffective) over- or underpasses have not been used to the favour of less expensive at-grade crossings. And necessary barriers for physical separation of lanes for different user groups are not expensive at all.

An overview of the result of the assessment is shown in table 6.

object	objective		assessment criterion
traffic	traffic safety		gravity of accidents/accident rates (++)
			speed behaviour of motorized traffic (+)
	good quality of traffic flow	public transport	accessibility of bus stops (++)
			quality of conveyance (+)
		motorized traffic	quality of driving comfort
		cyclists	quality of driving comfort (+)
			quality of crossing comfort (++)
		pedestrians	quality of walking comfort (+)
			quality of crossing comfort (++)
	good coverage of the area		parking facilities (+)
			quality of bus stops (++)
precincts/environment	Low space consumption		traffic areas
	social serviceability		low functional separating effect (+)
			amenity value (+)
design of street space	Orientation		recognition of direction and distance
	animation and composition		creation of space, scale and proportions (+)
cost-effectiveness	High cost-effectiveness		investment

table 6: evaluation of the improvements (green = important (++) or medium (+) improvement, yellow = no change, red = worsening)

List of figures

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