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Public transport improvements demonstration route project

Proposed Bus Priority Measures for Jl. Ahmad Yani, Surabaya

Final Draft, September 2001, Surabaya

GTZ's Sustainable Urban Transport Project (SUTP) in Surabaya aims to work with related agencies and the people of Surabaya to devise and implement policies toward environmentally, economically, and socially sustainable transport in the city.

This will result in a range of "local" economic (enhanced investment climate), social (poverty reduction) and environmental (cleaner air) benefits, and will also contribute to a stabilisation of "global" carbon dioxide emissions from Surabaya's transport sector. The project is hoped to provide a model of how to reduce such emissions from the transport sector in large cities in developing countries.

GTZ SUTP has embarked on an integrated program, including – working closely with the City Government – development of sustainable transport policies, design and implementation of a public awareness campaign, technical measures to reduce vehicle emissions, enhanced air quality management capability, adoption of appropriate fiscal instruments and transport demand management measures, improvement of conditions for non-motorized transport and pedestrians, elaboration of an effective inspection & maintenance and roadworthiness program, promotion of the use of CNG, a public transport demonstration route including regulatory and institutional reforms to be applied nationally if successful, and dissemination of international experiences.

GTZ SUTP commenced in Surabaya in 1998 and is due to finish in 2001.

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Contents

1. INTRODUCTION

1.1. Existing situation

Along the proposed demonstration bus route in Surabaya, which goes from Perak in the north to the main road outside Purabaya in the south, there is heavy peak hour traffic at Jl. Ahmad Yani resulting in heavy congestion every day. Bus speed surveys show this road to be the most congested point along the route, seriously affecting bus speeds. Therefore bus priority seems to be useful and necessary along this road.

The road is 3 laned in both directions (south/north) and physically divided by a median of about 3 meters width. The left southbound lane is very close to the railway, so there is no space to provide bus stops in between the edge of the road and the railway.

The length of the demonstration bus route following Jl. Ahmad Yani is about 5.5 km.

1.2. Basic concept

To combine the tasks of placing proper bus stops within very limited space and implement bus priority at this congested road, the idea of a bus lane next to the existing median was devised.

The basic idea provides several advantages:

- The existing median can be used to place sheltered comfortable bus stops, as it provides enough space.
- The bus stops are located at the left side of the vehicles, therefore all existing public transport vehicles can use the bus stops for passenger boarding and alighting.
- This bus stop on the left side of the vehicle is automatically given by the contra-flow design and by the with-flow design it is made possible with a bus stop pad design on the bus lane and the bus lane itself shifted to the existing median (see diagram).

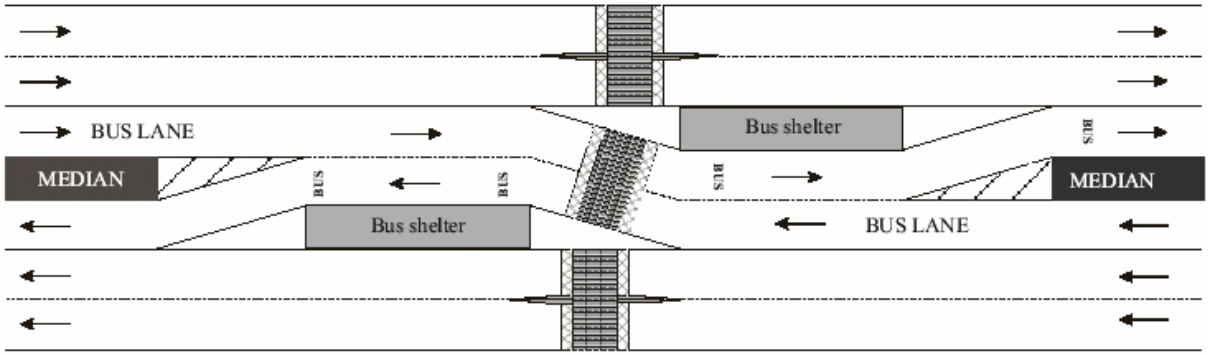


Diagram: Basic concept of the on-line median bus lane proposed for Jl. Ahmad Yani.

To realise this idea two main possibilities were considered: with-flow median bus lane, or contra-flow median bus lane.

The contra flow design was devised and discussed in detail in working reports, being available at GTZ SUTP. For reasons of discontinuity, complexity and safety, however, the contra flow option is not preferable, as the costs of the additional construction needed to implement the with flow option are not as high as innitially estimated. With the extra-cost being within the bounds of

reasonability and with the advantages of a continuous, simple and fairly safe measure the with flow option is strongly preferred and recommended.

The problem of enforcement of the with flow option is considered to be solved by placing concrete bollards as a physical divider, making it impossible for cars to use part of the bus lane by crossing over.

1.3. Other possible bus priority measures

Other possible bus priority measures like mixed traffic bus lanes and separated bus lanes/ways at the curb have been discussed in former working reports on bus priority. As the preferred option, the with-flow median bus lane option is outlined in detail in this report.

2. GENERAL CONSIDERATIONS ON THE CONCEPT

Along Jl. Ahmad Yani there are 2 major u-turns and 1 intersection (Margorejo) crossing the proposed bus lane. There is also the Jemur Sari intersection with several u-turns and a gas station accessible from both directions. Based on bus speed surveys and observations, The congestion area reaches from the Wonokromo area in the north to the Waru roundabout in the south and further. The Wonokromo area with its intersections and flyover is very complicated and poorly organised at the present state. There are a number of plans for changing the area, but the kind and date of implementation of the improvements, or whether they will be implemented at all, are uncertain at the time of designing the concept for bus priority.

One possibility to cope with these particular problems would be to plan changes and improvements to the Wonokromo area, implementing the bus lanes to the intersections as they exist at the moment, but this would not give a realistic chance of a fast implementation of the bus priority measure.

Because of this and the need for low cost measures, the start and end of the with-flow median bus lane in the north should be about 100 m south of the last entry/exit and u-turn facilities of the Wonokromo flyover.

However, in future plans for changing the Wonokromo intersection it is recommended to include bus priority in the planning process and extend the bus priority measures all the way to Jl. Darmo.

The start and end of the bus lanes in the south should be located 100 m north of the Waru roundabout, as it is close to the entry to Purabaya Terminal, which is only a few hundred metres from the southern end of the demonstration route. A range of 100 m at both locations (north and south) is considered to be enough space for buses to re-enter regular traffic flow from the bus lane.

For capacity reasons of the remaining lanes, the u-turns need a relatively high effort of construction, as to obtain space for queuing cars the bus lane needs to be shifted to the median. Also traffic lights are needed, as the cars have to cross two bus priority lanes before they re-enter regular traffic.

The Margorejo intersection is not a problem case for the implementation of the bus lane concept, as it is regulated by a traffic light.

At the Jemur Sari intersection the u-turn situation is less difficult compared to the other u-turns, as the approaches at the intersection are wide enough (about 14 metres) to implement an additional lane for queuing cars just by changing the road markings. Just south of the gas station the road needs to be widened, as shown in the detail diagrams. The northern u-turn at Jemur Sari is just a heavy vehicle u-turn, therefore providing a low pcu-volume. Further there is a police point right by the u-turn, so the conflicting traffic flows can be regulated by the police and just the physical divider bollards need to be spaced out at the u-turn. Same can be done at the gas station (space out bollards). The two u-turns at the south edge of the intersection need to be regulated by a traffic light. Also it is recommended to place a traffic light at the intersection itself, as the intersection does not function well without a traffic light and the light could also be used to adjust traffic flows approaching the u-turns.

3. VEHICLES PERMITTED TO USE THE BUS LANE

The new bus lane should not just be restricted to buses. It should also be used by microbuses and taxis.

All vehicles using the lane have to be forced only to stop at the bus stops for passenger boarding and alighting in order to ensure a continuous traffic flow along the lane, as there are no overtaking possibilities. Currently microbuses tend to stop indiscrimately, contributing substantially to congestion.

In the mid term allowing access to high occupancy vehicles (4 people or more) should be considered, but first the operation of the bus lane should be monitored. Allowing HOVs to use the bus lane would need to be coupled with strong law enforcement, as the optical difference in vehicles using the lane would not be as apparent.

4. REMAINING CAPACITIES AND IMPACT

There are many sources available stating the capacities of roads ranging from 1800 to 2300 passenger care units (pcu) per hour and lane. For Surabaya the capacity is assumed to be at the bottom end of this range, as quality of pavement and the driver discipline is relatively low. However, Jl. Ahmad Yani is a primary arterial road and because of this in relatively good condition. The capacity per lane should achieve 2000 pcu/h, but is stated in SITNP Stage II report no. A2 as 4300 per direction meaning a capacity per lane and direction as low as 1433 pcu/h. The Surabaya Road Traffic Office in discussion in June 2001 regarded the low capacity as caused by the high level of side friction partially caused by public transport vehicles (mostly microbuses) stopping on the lanes, and cars queuing for u-turns.

With the implementation of the bus lane the side friction would be reduced for the 2 remaining lanes. Therefore an increase of capacity at least to 1600 pcu/h for the remaining lanes is assumed, still a very cautious assumption.

With 2 remaining lanes the whole capacity of Jl. Ahmad Yani drops to 3200 pcu/h/direction. A traffic count in July 2001 indicated a peak hour traffic flow of 4100 pcu/h. This was surprisingly low compared to SITNP forecasts from 1997 which estimated the peak hour flow being 4800 pcu/h by 2001. This drop in volume is considered attributable to the ongoing effects of the economic crisis in 1997. The pcu share of buses is 2 %, microbuses 6 % and taxis 4 % along Jl. Ahmad Yani monitored through a screenline in June 2001. This makes a total share of 12 % of

pcus not using the remaining lanes any more and using the bus lane instead. Substracting the number of pcus using the bus lane, the remaining peak hour traffic flow for the 2 lanes is 4100*0,88 = 3608 pcu/h/direction, far exceeding the assumed maximum capacity of the remaining lanes. Therefore the implementation of the bus lane meaning a reduction of lanes for regular traffic down to 2 per direction has to be implemented simultaneously with the "odd and even" private motor vehicle restraint system which has already been proposed by the city government. Otherwise the levels of congestion would be excessive in the 2 remaining lanes. With the "odd and even" car restriction by plate number measure the peak hour traffic flow will be reduced by another 20 %. The remaining maximum peak hour traffic flow of the remaining lanes will be 2886 pcu/h/direction.

The existing V/C ratio is 4100/4300 = 0.95. With implementation of both, the "odd and even" car restriction and the bus lane the V/C ratio would drop down to 2886/3200 = 0.9 meaning an improvement of the existing situation. Also an increased use of public transport, resulting in a further decrease of regular traffic volumes, is assumed. The implementation of the suggested measures will therefore mean a win/win situation for both public and private transport.

5. DETAIL DIAGRAMS

5.1. Comments on the diagrams

The overview diagrams are not to scale. They should be considered as overview material to get an impression of the road, the area of the bus priority measure and to show the exact locations of the suggested bus stops. This is possible because the bus stops are either located at a distinctive point along the route or a distance to such a point is given.

The diagrams on the details are all to scale, although they do not show the variation of the actual lane widths at Jl. A.Yani. In the diagrams ranges of widths are given therefore. This has been done because of a lack of exact measuring tools and time. To make the necessary changes clear enough as a concept, these diagrams should be adequate. However, an exact survey of the existing widths is recommended to be taken before implementation. With this survey the lane widths can be easily adjusted.

5.2. Detail 1

Detail 1 shows the northern end of the bus lane immediately followed by a typical online bus stop pad layout, making boarding and alighting possible on the left side of the vehicle, as shown in the diagram. With the bus lane at the former median there is space to build a bus pad on the left side of the vehicle.

The layout of the bus stop itself can be seen in the bus stop diagrams. The same basic layout is used for all bus stop pads.

The pedestrian crossing is a raised zebra crossing, thought to be an effective method to enable a safe pedestrian crossing at relatively low cost, as explained later in this report.

Fences should be placed to prevent pedestrians from crossing the road outside the zebra crossings.

5.3. Detail 2

Detail 2 shows the layout of the existing u-turn with the bus lane shifted to the former median in order to have enough space for vehicles to queue without influencing the remaining capacities. To realise this detail, 4 additional traffic lights with a 2 group local controller are needed: one phase for buses and southbound traffic, one phase for u-turn vehicles. In order to guarantee safety to the bus lane shifted to the median, physical dividers of 10 cm curbs should be set on both sides. The calculation of the traffic light setup for southbound traffic and u-turn traffic turned out queue lengths of 298 m (southbound) and 140 m (u-turn). The distance from the Margorejo intersection to the u-turn is just 300 m, letting the queue get very close to the intersection, but the length is calculated with many safety factors (already maximum peak hour traffic flow used for design and additional maximum car number raised for a probability of overload less than 5%). The regular queue length southbound should in reality not exceed 70*20/6,5 = 215 m making interference with the Margorejo intersection unlikely.

5.4. Detail 3

Detail 3 is similar to Detail 1. The difference is that it is directly followed by Detail 2. Therefore the layout of one bus pad had to be modified.

Another difference is that at this point and also at the following details there is a drainage canal under the existing median. The layout of an option to mostly maintain the existing drainage while still shifting the lane is shown later in the report.

5.5. Detail 4

The centre point of Detail 4 is located right at the existing pedestrian bridge at Jl. A.Yani. The layout of the bus stop pads makes the pedestrian bridge unnecessary and also the structure of the bridge makes the suggested changes impossible. Therefore it needs to be torn down. Modifying the bridge to access the pads is impractical, as most pedestrians prefer to cross the street on the ground than to use the bridge, even if they are taking the high risk of getting hit by a car. The design of the bus pads is similar to the others.

5.6. Detail 5

The southern edge of Detail 5 is located at the northern point of the Jemursari intersection, where the road is widened by cutting into the median. Because of this already existing widening one bus stop pad has to be modified, as shown in the diagram. The remaining layout features are unchanged.

5.7. Detail 6

Detail 6 shows the changes required to the southern part of the Jemursari intersection in order to maintain the bus lane through this area. In the southern part the road needs to be slightly widened to provide an extra lane for queuing cars. The approaches to the intersection are wide enough to enable provision of the extra lane by simply rearranging the road markings. At the entries and exits of the gas station the physical divider bollards need to be spaced out as shown in the diagram. To maintain the u-turns, traffic lights are needed: 4 lamps with a 2 group controller. One phase for buses and one phase for u-turning traffic.

Due to a lack of time, there is no queue calculation available for these u-turns.

5.8. Detail 7

The beginning of Detail 7 is located 25 m south of the southern edge of Jl. Gayung Kebonsari. The detail itself shows the typical bus stop pad layout.

5.9. Detail 8

Detail 8 is similar to Detail 2, but on the other lane, because the u-turn is in the other direction, so there is no need to discuss the changes again.

The difference is the queuing space and therefore the shift of the bus lane needs to be slightly longer, as the calculation turned out a queue length of 160 m in this location. The queue length of the northbound traffic will be a calculated 320 m.

5.10. Detail 9

Detail 9 is located at the existing pedestrian traffic light at the end of Jl. Siwalankerto. As this traffic light is already existing it should be maintained with the implementation of the bus stop pads. The pads just need to be built around the facility, as shown in diagram. The existing signalisation also obviates the need for implementation of the raised zebra crossing at this location. The remaining layout is similar to the other pads except for the fact that the northern pad is on the right side, and the southern on the left.

5.11. Detail 10

Detail 10 shows the last bus stop in southbound direction, with standard layout features.

6. CONSTRUCTION DETAILS (DRAINAGE)

In general no extraordinary construction work is needed to implement the bus lane, though attention must be given to maintaining the existing drainage at the median, so that the flooding problem is not exacerbated. The solution for this problem would be to place precast interrupted concrete ledges on a concrete subconstruction replacing the existing drainage, but easily connected to the existing system of drainage. These concrete ledges are considered to be the best solution to keep down construction costs. Steel plates would be five times more expensive. In addition, changing the drainage system to a subroad construction would only make sense if done for the whole length of the road.

A typical layout of such a ledge, the subconstruction, and the static calculations can be seen in the diagram below.

Before implementation it is recommended to have the correctness of the static calculations and especially the load assumptions verified by a stress analyst.

7. PEDESTRIAN CROSSINGS

At present the pedestrian crossing situation along Jl. Ahmad Yani is very poor, as very few crossing facilities exist along the road and crossing the road without a proper facility is almost impossible for reasons of long crossing distance (10m), and high speeds and high volumes of vehicles. Long waiting times are common to find a gap to cross the distance and even then still in conjunction with high risk of getting hit by a car. Along with the implementation of the bus lane,

there will be an increase in pedestrians crossing the street to get on and off the median, as this would be the designated place for bus stops.

For these reasons great attention must be paid to pedestrian crossing facilities enabling a safe passage to and from the median.

To solve the problem of the provision of safe pedestrian crossing a raised zebra crossings in combination with small pedestrian islands is recommended. Additionally an attendant should help the pedestrians to cross for at least the first 6 months after implementation, until users are familiar with the new situation. A typical design of such a pedestrian crossing is shown in diagrams.

The idea of the raised zebra crossing is taken from the World Bank Sub-Saharan Africa Transport Programme's publication "Liveable African Cities: A guideline for urban pedestrian and bicycle traffic in Africa," where positive experiences have been documented with this kind of facility. At a particular road those raised zebra crossings were implemented and surveyed over a period of 1 year. The surveys showed the following effects:

- Traffic accidents at the section were virtually eliminated, safe crossing is possible and safety of cycling has also improved.
- An increased use of busbays has been monitored.
- For motor vehicle movement the cost of damage to cars has been reduced and the average transit time did not increase significantly at this road section.
- Unfortunately the pedestrian waiting time did not decrease, because the slowing down did not influence the size and distribution of the inter-vehicle gaps and the drivers' willingness to give priority to the pedestrians did not increase.
- Good visibility of the zebra crossing because of different surface is achieved.

Based on these monitored effects and expert recommendations, the implementation of raised zebra crossings at Jl. A. Yani is regarded as the best way to guarantee a safe crossing for pedestrians to and from the median. However, Jl. Ahmad Yani has a very high traffic volume, probably much higher than the test road in Africa. For this reason and considering the fact of 2 lanes needed to be crossed with no increase in inter vehicle gaps, as monitored already in Africa, additional pedestrian islands are needed to enable a convenient crossing facility.

In the diagram two different versions are shown of the zebra crossing surface material. Version A shows the same material as used in Africa where tests have shown that brick pavement is stronger than bitumen pavement on top of a raised zebra. Version B is assumed to be even stronger than brick pavement, as the whole construction consists of concrete.

The advantage of version A is the positive experience with it in Africa already, proving the durability and benefits. Version B on the other hand is much easier to construct. The method of construction would stay the same in cutting the existing road surface and setting the pre-cast ramp block, but after these 2 steps version B is much simpler, as no extra surface cutting is necessary for the sand layer and concrete could just be set on the existing surface. Not even shaping would be needed, as it is already shaped by the ramp blocks and the median. Just one side remains open, which can be closed easily. Version B is therefore cheaper, too. In the total sum of the cost calculations, therefore, the preferred option B is included.

The layout of the pedestrian islands is shown in the detail diagrams discussed earlier, but the actual width has to be fitted to the present width of Jl. A.Yani at the exact location the crossing is

implemented for every bus stop. In the diagrams the *minimum* widths are shown. Hence, depending on the actual width of Jl. A.Yani, the islands should be widened from the minimum width of 60 cm as far as it is possible while not narrowing the lanes further than the 2.75 m minimum width of lanes used by buses and trucks. A width of 3 meters should be maintained wherever possible for the bus lane.

To enforce pedestrians' right of way at the zebra crossings it is recommended to employ an attendant at each crossing for at least the first 6 months after implementation of the crossings and the bus lane. This would give both the car/bus drivers and pedestrians time to get used to the new situation without the risk of major accidents. Such an attendant is already often on duty on Jl. A. Yani outside the Purabaya Terminal. With a signaling disc, traffic is stopped by the attendant to enable pedestrians to cross the road on demand.

To make sure pedestrian do not cross the street close to the crossing facility without using it, a basic iron fence should be mounted on top of the pedestrian islands. A reflecting pole should be provided at the beginning of the island to ensure vehicle drivers are aware of the island and prevent accidents.

8. IMPLEMENTATION OF THE BUS PRIORITY MEASURES

8.1. Cost estimations

The cost estimations are based on the current version of the "Standard Book for Material Prices and Labor Cost" of the Surabaya Municipality from the year 2000. Although the local authorities are still using these prices, due to the ongoing currency instability and weakness it is recommended to use an adjustment factor for funding. Such a factor is not yet included in the estimations. In any case proofed actual prices can only be obtained by a bidding process between local construction companies.

8.2. Consultation with the local authorities (Road Traffic Office)

From the beginning of planning on the concept of a bus priority measure at A.Yani there has been positive feedback and interest from the local authorities. In several states of revision of the concept the local authorities have been involved in the detailed layout of the concept. In early July 2001 an initial presentation of the bus lane concept (contra flow) was delivered at the Road Traffic Office with a positive feedback. The feedback was incorporated and further advice was received from Lloyd Wright, an expert on bus priority measures, stressing the need to carefully consider the extra complexity and problematic safety aspects entailed with a contra-flow scheme. Based on this advice and further consultation and discussion, the contra-flow option was abandoned in favour of a with-flow option similar to the scheme used in Porto Alegre and Quito, Brazil. A presentation of the median bus lane concept was then made in late July 2001, jointly by GTZ SUTP and the City Road Traffic Office.

8.3. Work still required

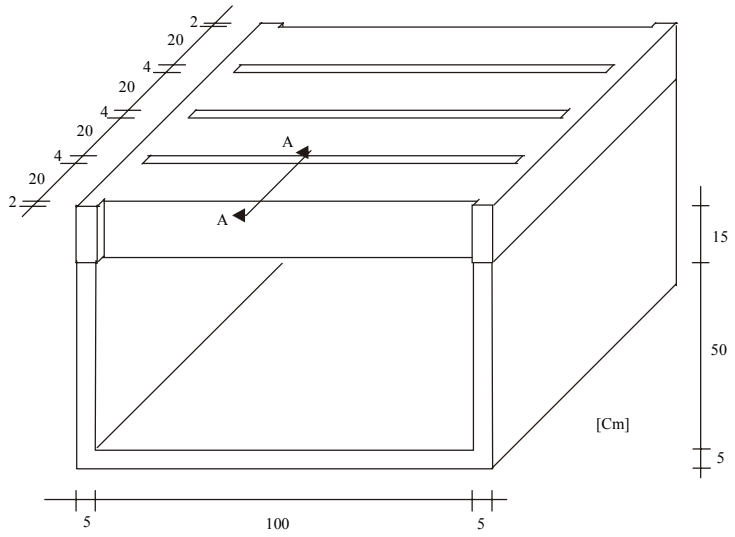
The elaborated concept is ready for implementation if the recommended validations and the exact land surveys with precise measuring tools are taken. With the results of the survey the diagrams can be easily adjusted and implementation can begin.

These land surveys are not yet included in the cost estimations, but need to be taken before any construction work.

Therefore it is recommended to include the survey work and the responsibility for the surveys in the work descriptions of the tender documents and start the tender process. This way the tender process is ready to start, except for the validation of the calculation which needs to be done before the preparation of the tender documents. In addition, by taking this course the cost estimations can be proofed by the advertised bidding process.

8.4. Static calculations of on concrete ledges above existing drainage

8.4.1. Design of ledge



8.4.2. Load assumptions

The heaviest vehicles using bus lanes will be the buses.

The load of a full bus is assumed to be 10 tons.

On any circumstances the maximum load to be beared by the ledges is the load of one axle of the bus.

→ P_{max} = 5 tons = 50 kN.

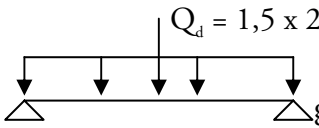
The maximum load to be beared by one stripe is the load of one wheel:

→ P_{max} = 50/2 = 25 kN

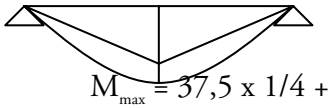
Dead weight of concrete structure:

With the striped design of the sledges (to maintain drainage) the cross section of the ledges will be 0,2m x 0,1m → g = 0,2x0,1x25 = 0,5 kN/m

8.4.3. Load bearing structure



1 m



M_{max} = 37,5 x 1/4 + 0,675 x 1²/8 = 9,46 kNm

8.4.4. Required reinforcement (Eurocode 2)

Concrete. C20/25 (f_{ck} = 20 N/mm²); with regular concrete reinforcement steel BSt 500 (β_S = 500 N/mm²)

Bend reinforcement:

M_{Sd} = 0,00946 MNm

d = 0,15 – 0,02 – 0,01 – 0,012 = 0,108 m

M_{Sds} = 0,00946/(0,2x0,108²x20/1,5) = 0,304

ω = 0,4015

$A_{S,req}$ = 1/435x0,4015x0,2x0,108x20/1,5 = 2,66 cm²

4 ∅ 10 mm reinforcement steel required per stripe

Vertical Forces reinforcement:

V_{Sd} = 18,75 kN

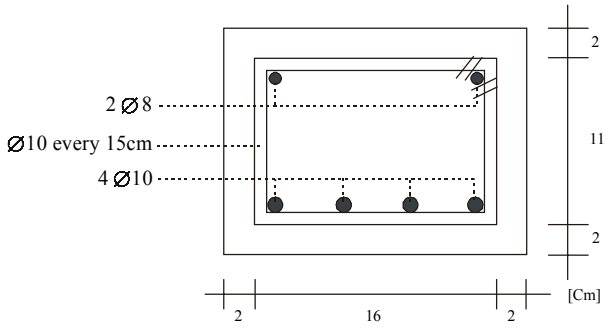
V_{Rd1} = 0,24x1,525x1,36x0,2x0,108 = 10,75 kN

V_{Rd2} = 0,5x8x0,2x0,9x0,108 = 77,76 kN > 38 kN

$a_{sw'}$ = (38-10,75)/(435x0,9x0,108) = 6,4 cm²/m

→ ∅ 8 mm/15 cm 2 cut shackles

Reinforcement diagram:



8.4.5. Subconstruction

The concrete subconstruction is chosen, because the load of 37,84 kN would mean too much pressure not being able to be borne by the solid.

With the concrete construction no special proof is needed, because the pressure produced by the load (37,84/0,1 = 0,3784 N/mm²) is very low compared to the concrete's ability to resist pressure (20 N/mm²). Therefore just constructive reinforcement is needed.

9. TRAFFIC LIGHT AND QUEUE CALCULATION OF U-TURNS (DETAIL 2/8)

The calculations are based on the "Indonesian Highway Capacity Manual", February 1997 from the RI Directorate of urban road development (BINKOT).

9.1. Northern U-turn (Detail 2)

Relevant traffic data:

Max. Peak hour traffic (Survey 4.7.2001):

Southbound: 4100 pcu/h

U-turn: 481 pcu/h

This is the traffic flow data with a pce-factor of 0.4 for motorcycles. With the implementation of the bus lane, the odd and even and the planned traffic light (protected approach; pce for motorcycles 0.2 the flows need to be used for the calculation will be as followed:

Southbound: 2437 pcu/h

U-turn: 204 pcu/h

$W_{e,u}$ = 3 m (index u for u-turn approach)

$W_{e,s}$ = 6,5 m (index s for southbound approach)

Base Saturation:

$S_o = 600 \times W_e$

Side Friction adjustment factor:

0.93 for high level of side friction in commercial area

Other Saturation adjustment factors are set 1.

→ S_u = 600 x 3 x 0,93 = 1674 pcu/hg

S_s = 600 x 6,5 x 0,93 = 3627 pcu/hg

Flow/Saturation Flow ratios:

FR_u = 204 / 1674 = 0,12

FR_s = 2437 / 3627 = 0,67

Intersection Flow Ratio:

IFR = 0,79

Phase ratios:

PR_u = 0,12/0,79 = 0,15

PR_s = 0,67/0,79 = 0,85

Cycle and green times:

c_{ua} = (1,5 x LTI + 5) / (1-IFR) (unadjusted cycle time)

with LTI (Lost time per cycle) = 4 sec. for small intersection size

c_{ua} = (1,5 x 4 + 5) / (1-0,79) = 52 sec.

g_u = (52-4) x 0,15 = 8 sec (greentime); greentimes should not be shorter than 10 sec.

→ g_u set to 10 sec.

→ c_{ua} = 10/0,15 + 4 = 71 sec.

g_s = (71-4) x 0,85 = 57 sec.

→ c = 10 + 57 + 4 = 71 sec (adjusted cycle time)

Capacities:

C = S x g/c

C_s = 3627 x 57/71 = 2912

C_u = 1674 x 10/71 = 236

Degrees of Saturation:

DS_s = 2437/2912 = 0,84

DS_u = 204/236 = 0,86

Green ratios:

$GR_s = 57/71 = 0,8$

$GR_u = 10/71 = 0,14$

Queue lengths:

$N_{Q1} = 0,25 \times C \times ((DS-1)^2 + \sqrt{(8 \times (DS-0,5)/C))}$ (Number of vehicles remaining after one cycle)

$N_{Q1s} = 0,25 \times 2912 \times ((0,84-1)^2 + \sqrt{(8 \times (0,84-0,5)/2912)) = 40,88}$

$N_{Q1u} = 0,25 \times 236 \times ((0,86-1)^2 + \sqrt{(8 \times (0,86-0,5)/236)) = 5,7}$

$N_{Q2} = c \times (1-GR)/(1-GR \times DS)$ (Number of vehicles arriving during red)

$N_{Q2s} = 71 \times (1-0,8)/(1-0,8 \times 0,84) = 29,3$

$N_{Q2} = 71 \times (1-0,14)/(1-0,14 \times 0,86) = 3,9$

$N_{Qs} = 70$; $N_{Qu} = 10$

With a desired Probability of Overloading lower than 5%

→ $N_{Q\,max\,s} = 97$; $N_{Q\,max\,u} = 21$

→ $Q_{Ls} = 97 \times 20/6,5 = 298$ m ; $Q_{Lu} = 21 \times 20 / 3 = 140$ m

9.2. Southern U-turn (Detail 8)

Relevant traffic data:

Max. Peak hour traffic (Survey 4.7.2001):

Northbound: 4100 pcu/h

U-turn: 595 pcu/h

This is the traffic flow data with a pce-factor of 0.4 for motorcycles. With the implementation of the bus lane, the odd and even and the planned traffic light (protected approach; pce for motorcycles 0.2 the flows need to be used for the calculation will be as followed:

Southbound: 2339 pcu/h

U-turn: 485 pcu/h

$W_{e,u} = 3$ m (index u for u-turn approach)

$W_{e,s} = 6,5$ m (index s for southbound approach)

Base Saturation:

$S_o = 600 \times W_e$

Side Friction adjustment factor:

0.93 for high level of side friction in commercial area

Other Saturation adjustment factors are set 1.

→ $S_u = 600 \times 3 \times 0{,}93 = 1674$ pcu/hg

$S_s = 600 \times 6{,}5 \times 0{,}93 = 3627$ pcu/hg

Flow/Saturation Flow ratios:

$FR_u = 485 / 1674 = 0{,}29$

$FR_s = 2339 / 3627 = 0{,}64$

Intersection Flow Ratio:

IFR = 0,93

Phase ratios:

$PR_u = 0{,}29/0{,}93 = 0{,}31$

$PR_s = 0{,}64/0{,}93 = 0{,}69$

Cycle and green times:

c_{ua} = (1,5 x LTI + 5) / (1-IFR) (unadjusted cycle time)

with LTI (Lost time per cycle) = 4 sec. for small intersection size

$c_{ua} = (1{,}5 \times 4 + 5) / (1-0{,}93) = 157$ sec.

Too long → 80 sec chosen

$g_u = (80-4) \times 0{,}31 = 24$ sec (greentime); greentimes should not be shorter than 10 sec.

$g_s = (80-4) \times 0{,}69 = 53$ sec.

→ c = 24 + 53 + 4 = 81 sec (adjusted cycle time)

Capacities:

C = S x g/c

C_s = 3627 x 53/81 = 2373

C_u = 1674 x 24/81 = 496

Degrees of Saturation:

DS_s = 2339/2373 = 0,98

DS_u = 485/496 = 0,98

Green ratios:

GR_s = 53/81 = 0,65

GR_u = 24/81 = 0,30

Queue lengths:

$N_{Q1} = 0{,}25 \times C \times ((DS-1)^2 + \sqrt{(8 \times (DS-0{,}5)/C)})$ (Number of vehicles remaining after one cycle)

$N_{Q1s} = 0{,}25 \times 2373 \times ((0{,}98-1)^2 + \sqrt{(8 \times (0{,}98-0{,}5)/2373)}) = 24{,}1$

$N_{Q1u} = 0{,}25 \times 496 \times ((0{,}98-1)^2 + \sqrt{(8 \times (0{,}98-0{,}5)/496)}) = 11$

$N_{Q2} = c \times (1-GR)/(1-GR \times DS)$ (Number of vehicles arriving during red)

$N_{Q2s} = 81 \times (1-0{,}65)/(1-0{,}65 \times 0{,}98) = 50{,}7$

$N_{Q2} = 81 \times (1-0{,}3)/(1-0{,}3 \times 0{,}98) = 5$

N_{Qs} = 75 ; N_{Qu} = 16

With a desired Probability of Overloading lower than 5%

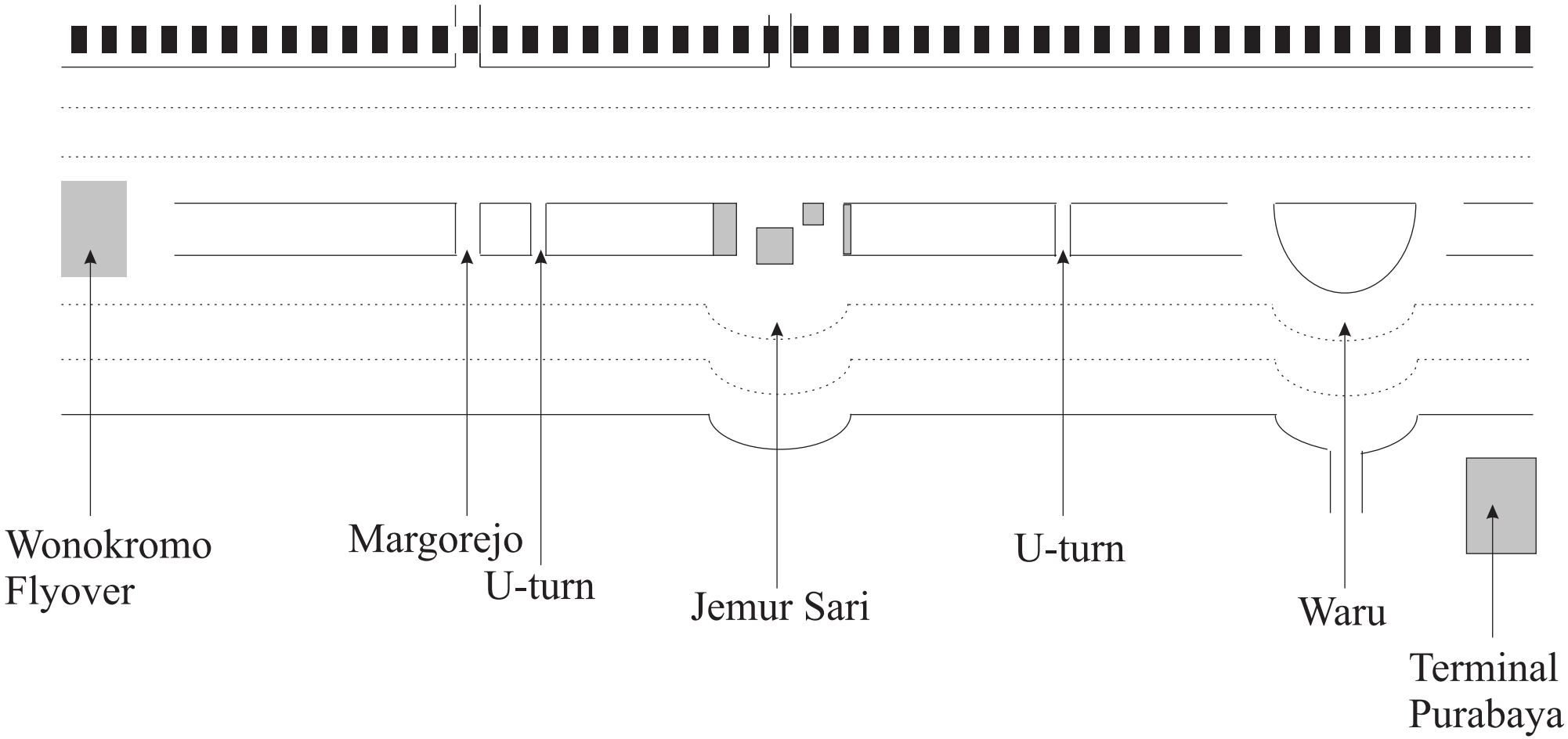
→ $N_{Q\,max\,s}$ = 103; $N_{Q\,max\,u}$ = 24

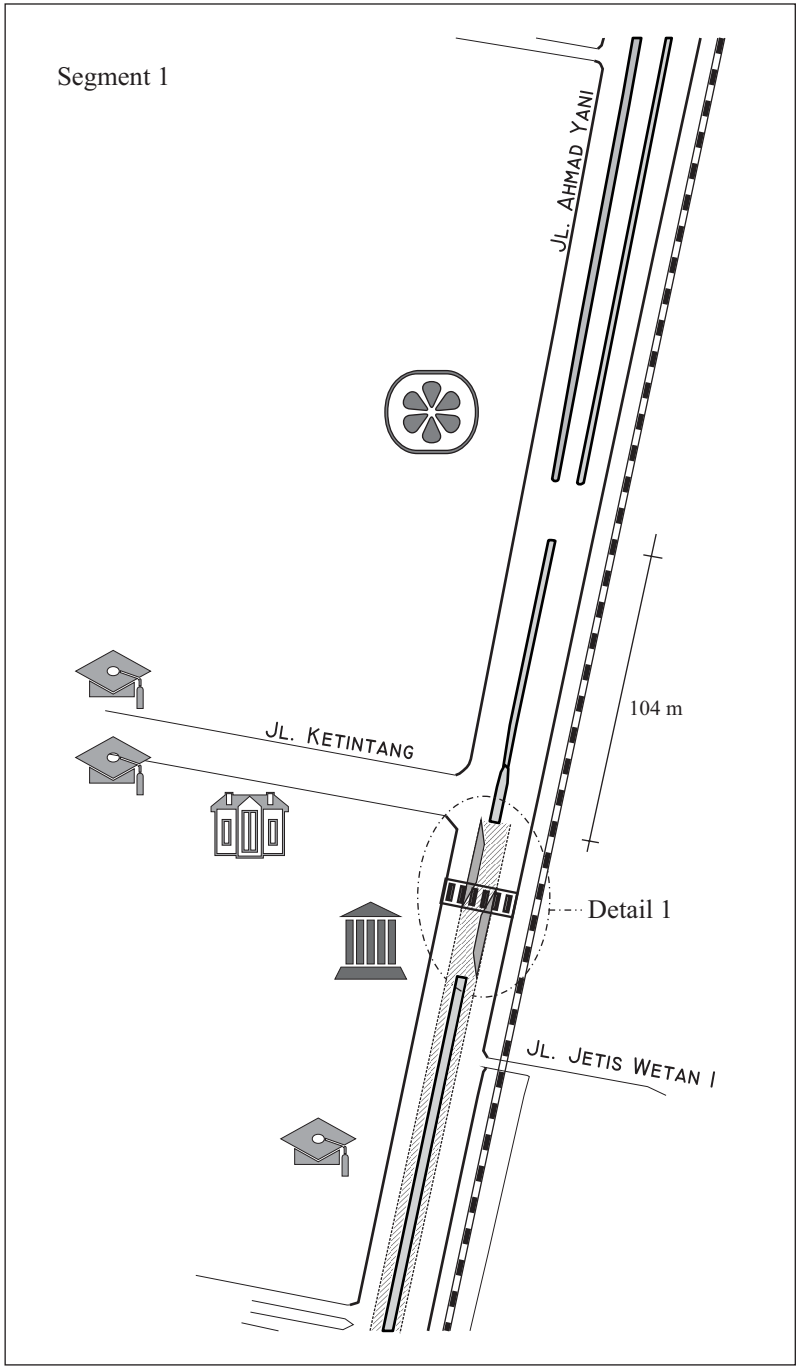
→ Q_{Ls} = 103 x 20/6,5 = 320 m ; Q_{Lu} = 24 x 20 / 3 = 160 m.

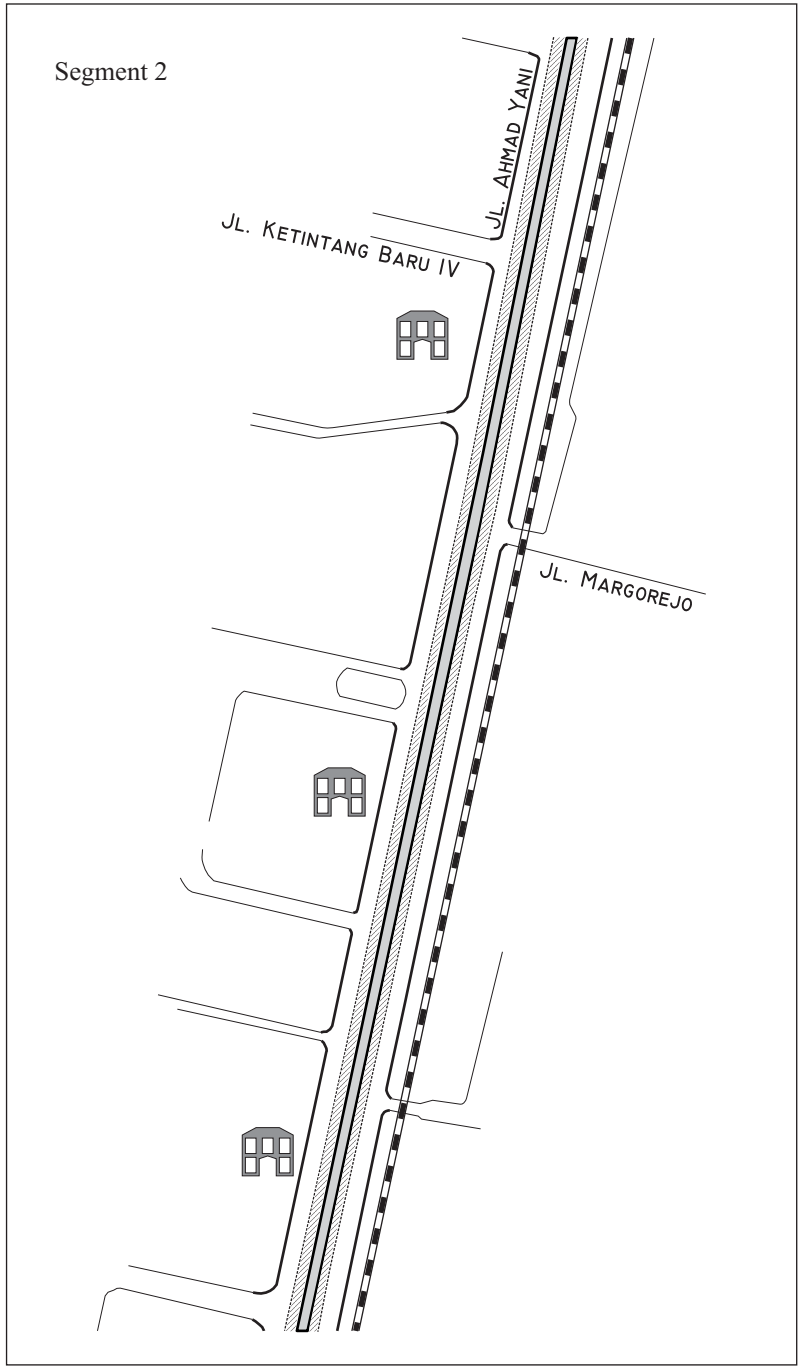
10. DETAIL DIAGRAMS

(See pages 18 – 36 following.)

Overview of Jl. A. Yani







Suggested Bus priority measures at Jl. A.Yani

Overview of With flow option

Segment 1 and 2 of 11 in North - South direction

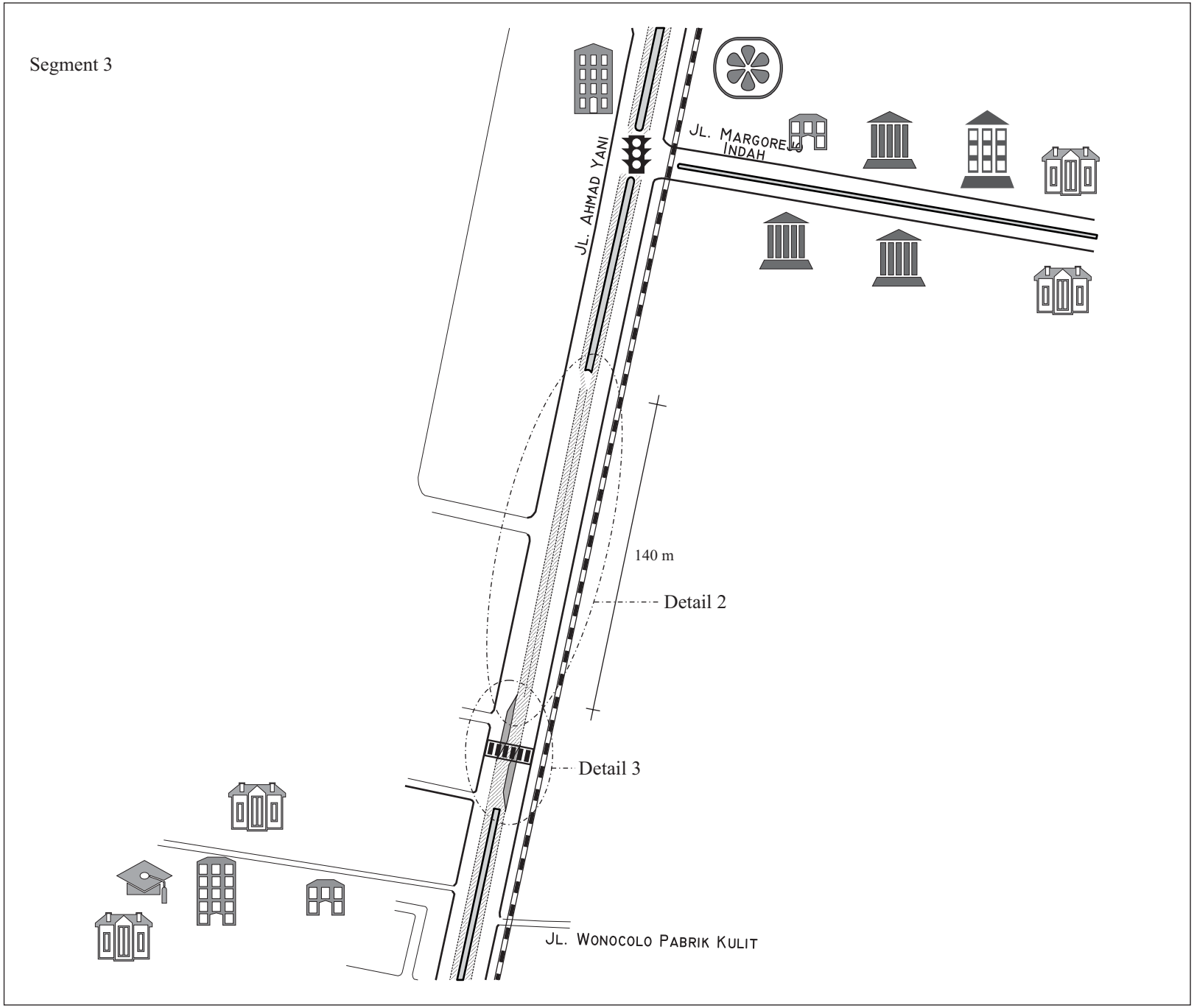
North

Non scaled

Road inventory by
Endri Sutjahjo
Jan 2001

Edited by
Frank Kraatz

With flow bus lane



Suggested
Bus priority
measures
at Jl. A.Yani

Overview of
With flow
option

Segment 3 of 11
in North - South
direction

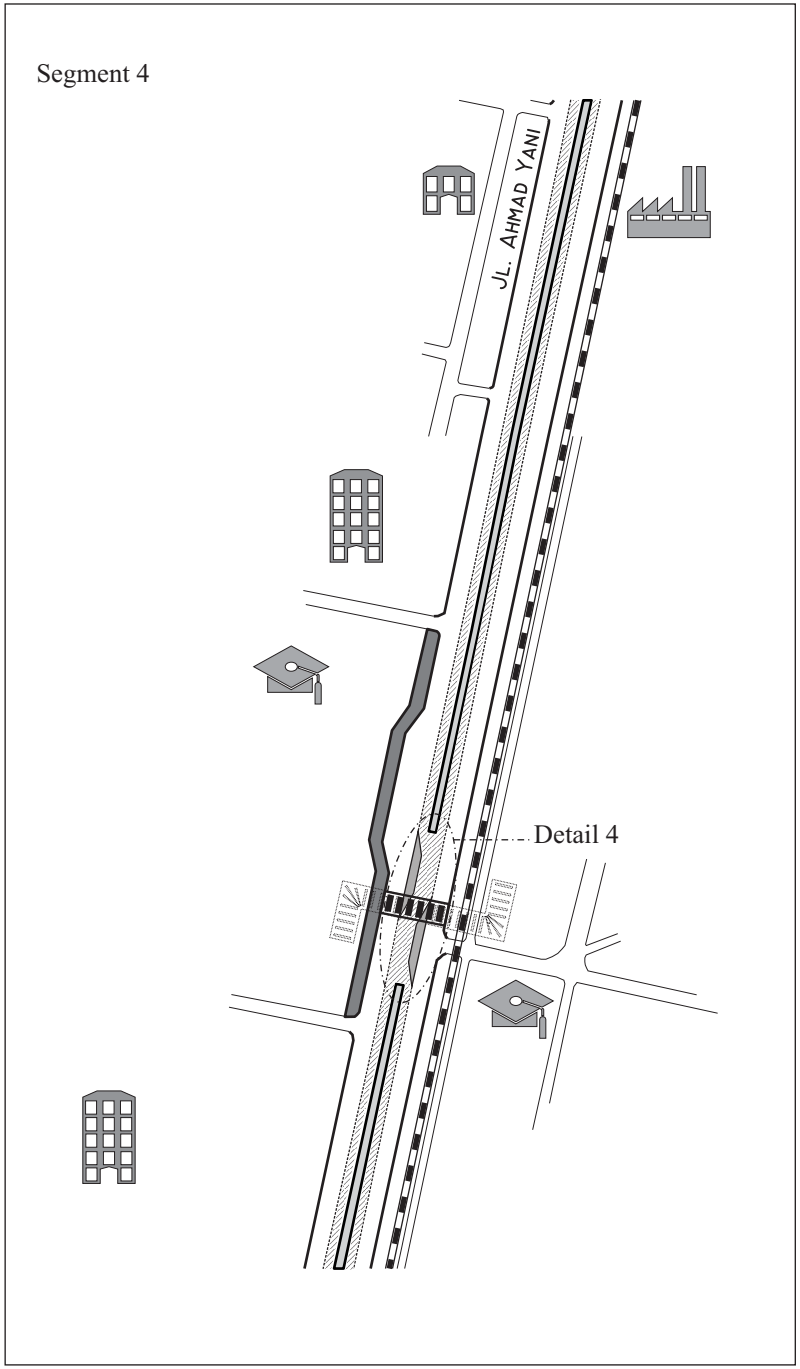
North

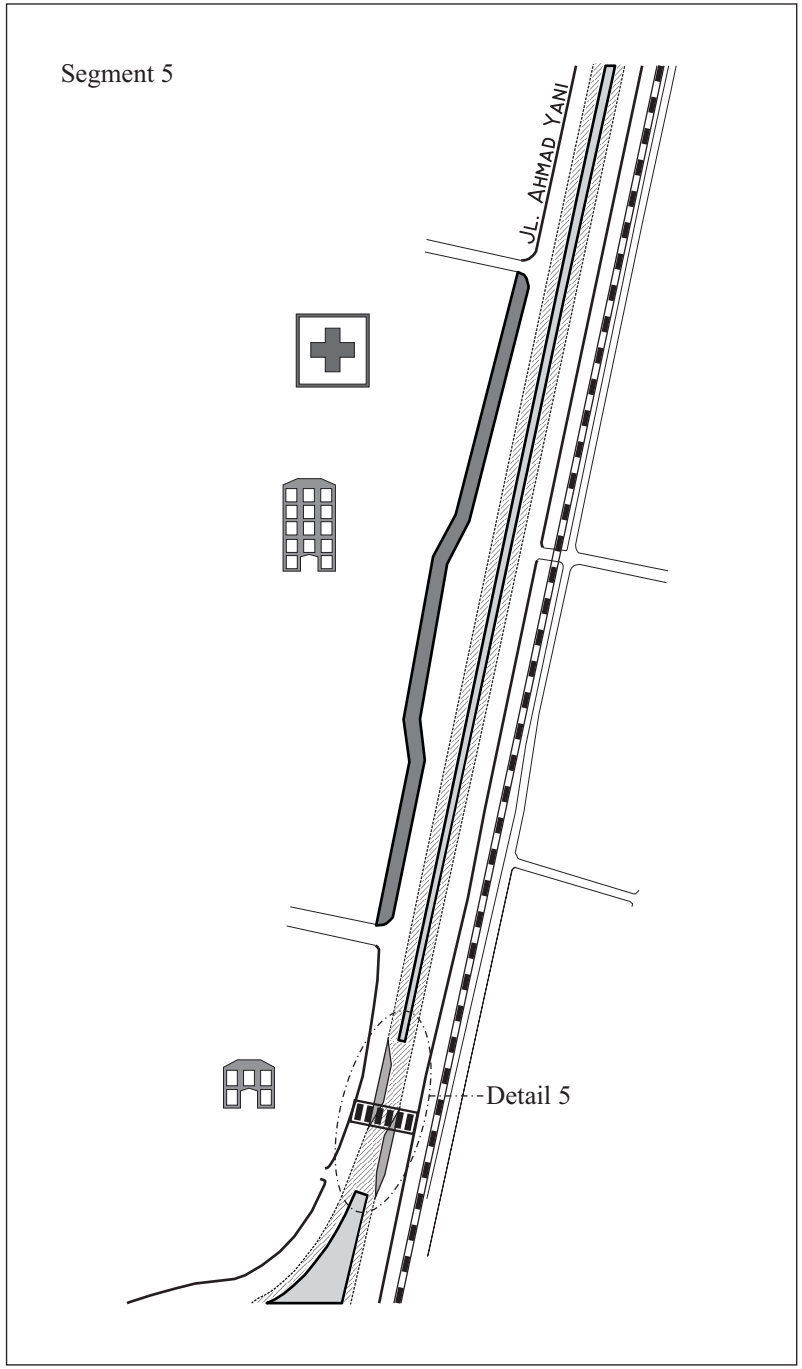
Non scaled

Road inventory
by
Endri Sutjahjo
Jan 2001

Edited by
Frank Kraatz

With flow
bus lane





Suggested Bus priority measures at Jl. A.Yani

Overview of With flow option

Segment 4 and 5 of 11 in North - South direction

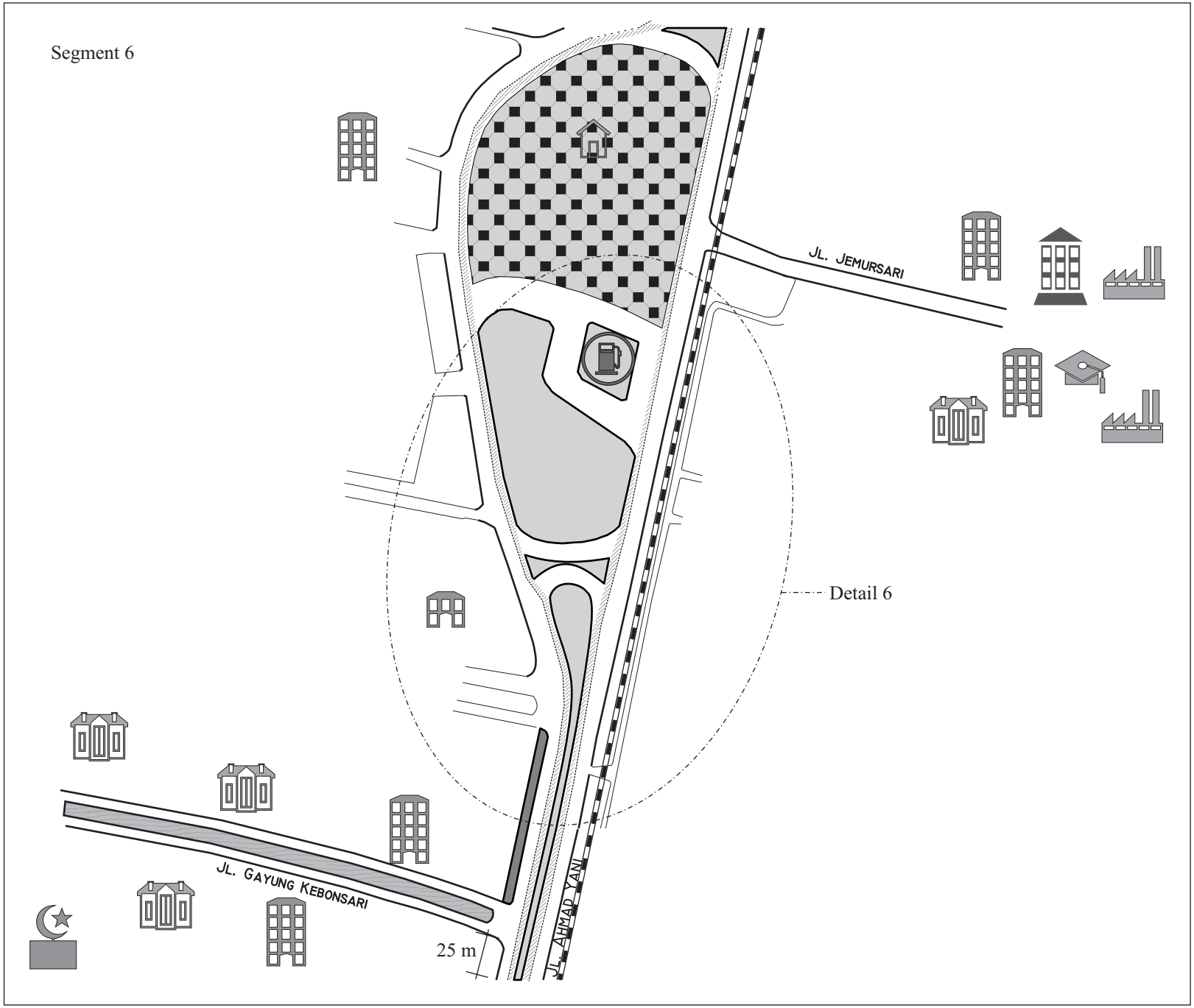
North

Non scaled

Road inventory by
Endri Sutjahjo
Jan 2001

Edited by
Frank Kraatz

With flow bus lane



Suggested
Bus priority
measures
at Jl. A.Yani

Overview of
With flow
option

Segment 6 of 11
in North - South
direction

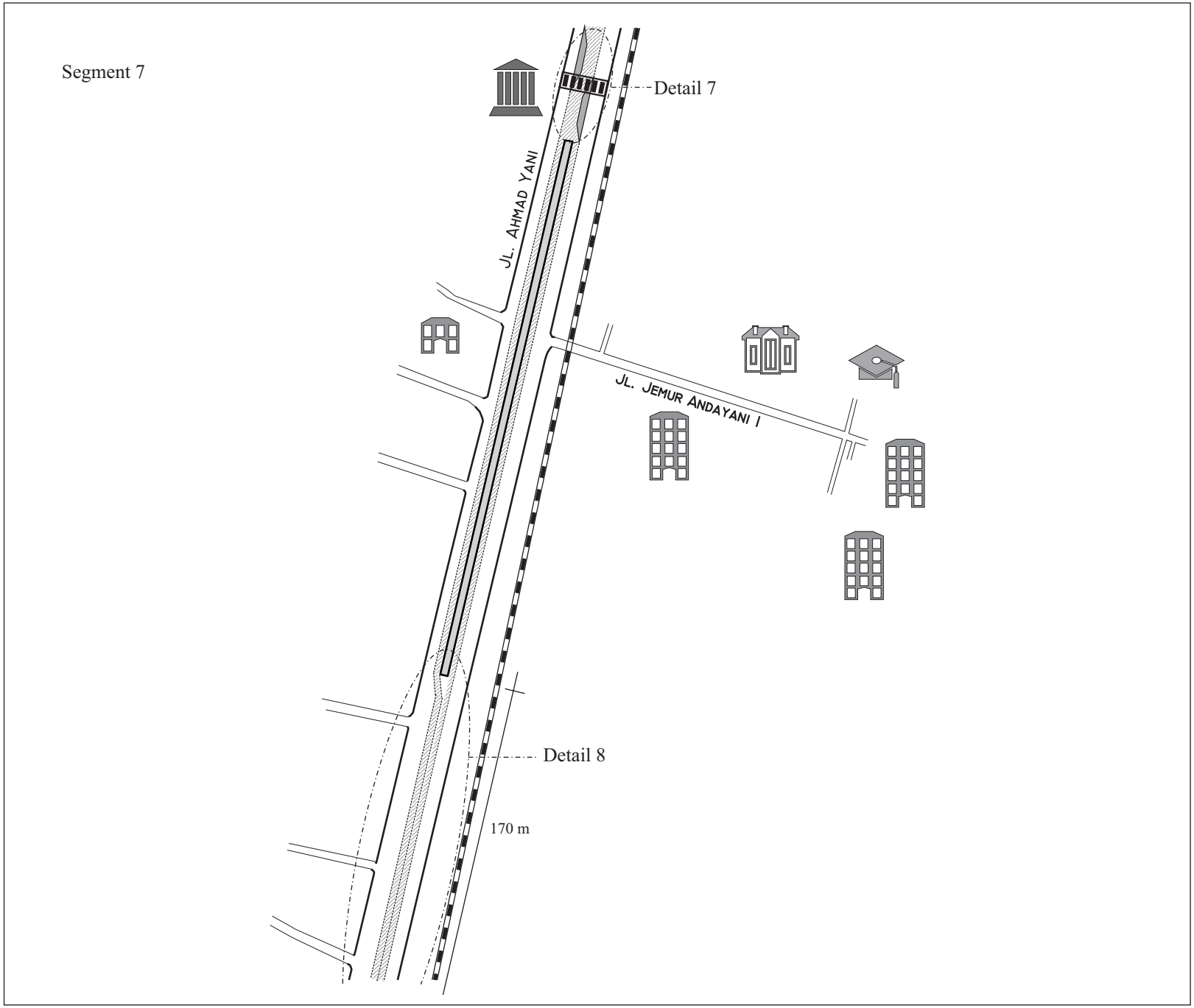
North

Non scaled

Road inventory
by
Endri Sutjahjo
Jan 2001

Edited by
Frank Kraatz

With flow
bus lane



Suggested Bus priority measures at Jl. A.Yani

Overview of With flow option

Segment 7 of 11 in North - South direction

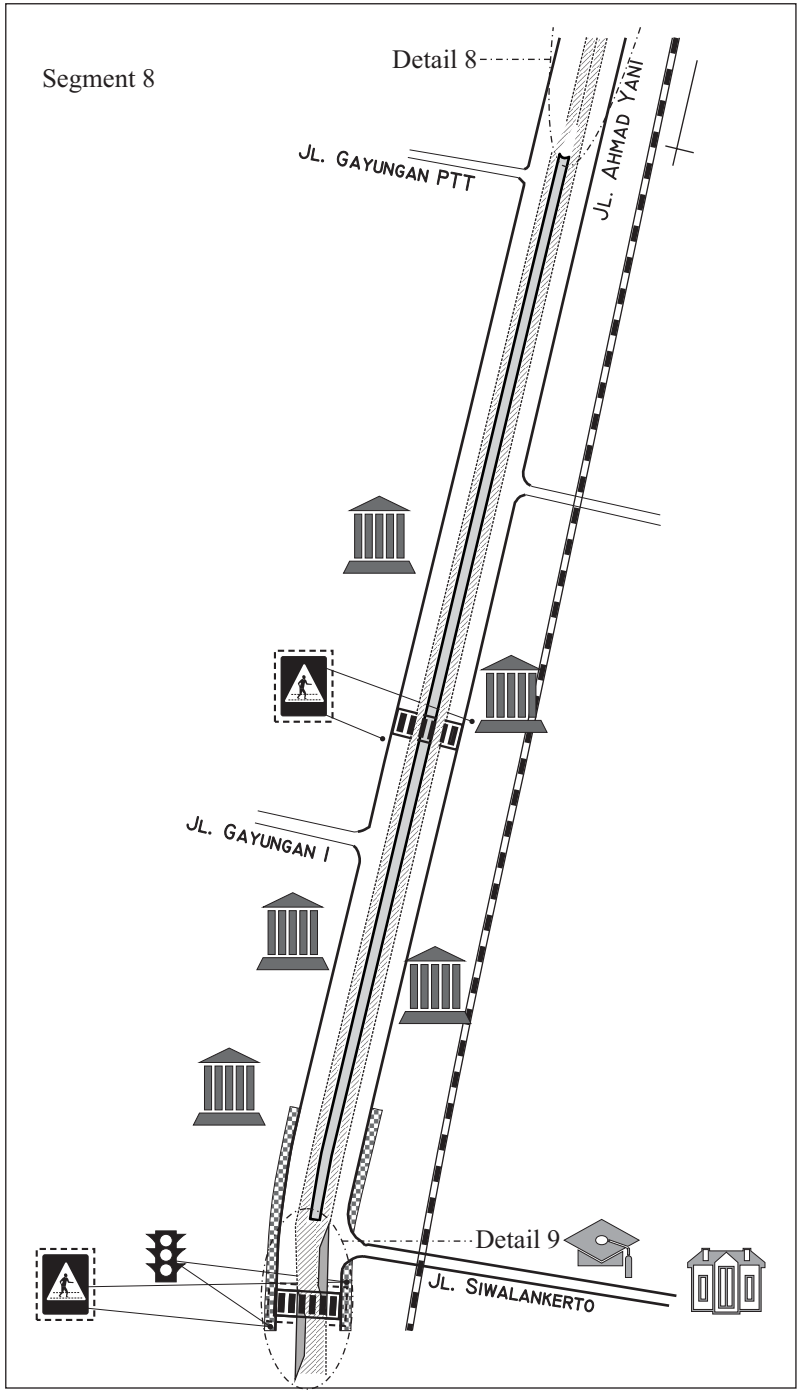
North

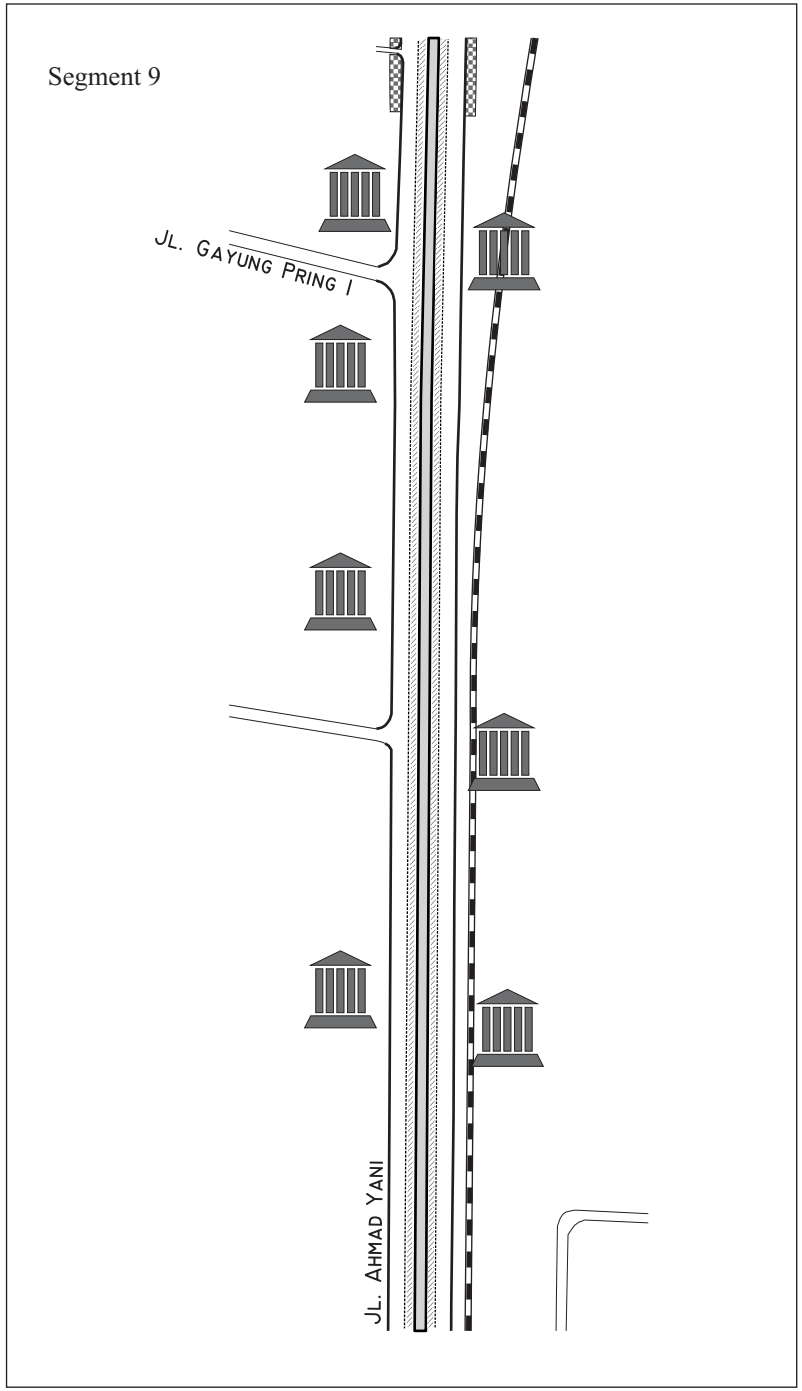
Non scaled

Road inventory by
Endri Sutjahjo
Jan 2001

Edited by
Frank Kraatz

With flow bus lane





Suggested Bus priority measures at Jl. A.Yani

Overview of With flow option

Segment 8 and 9 of 11 in North - South direction

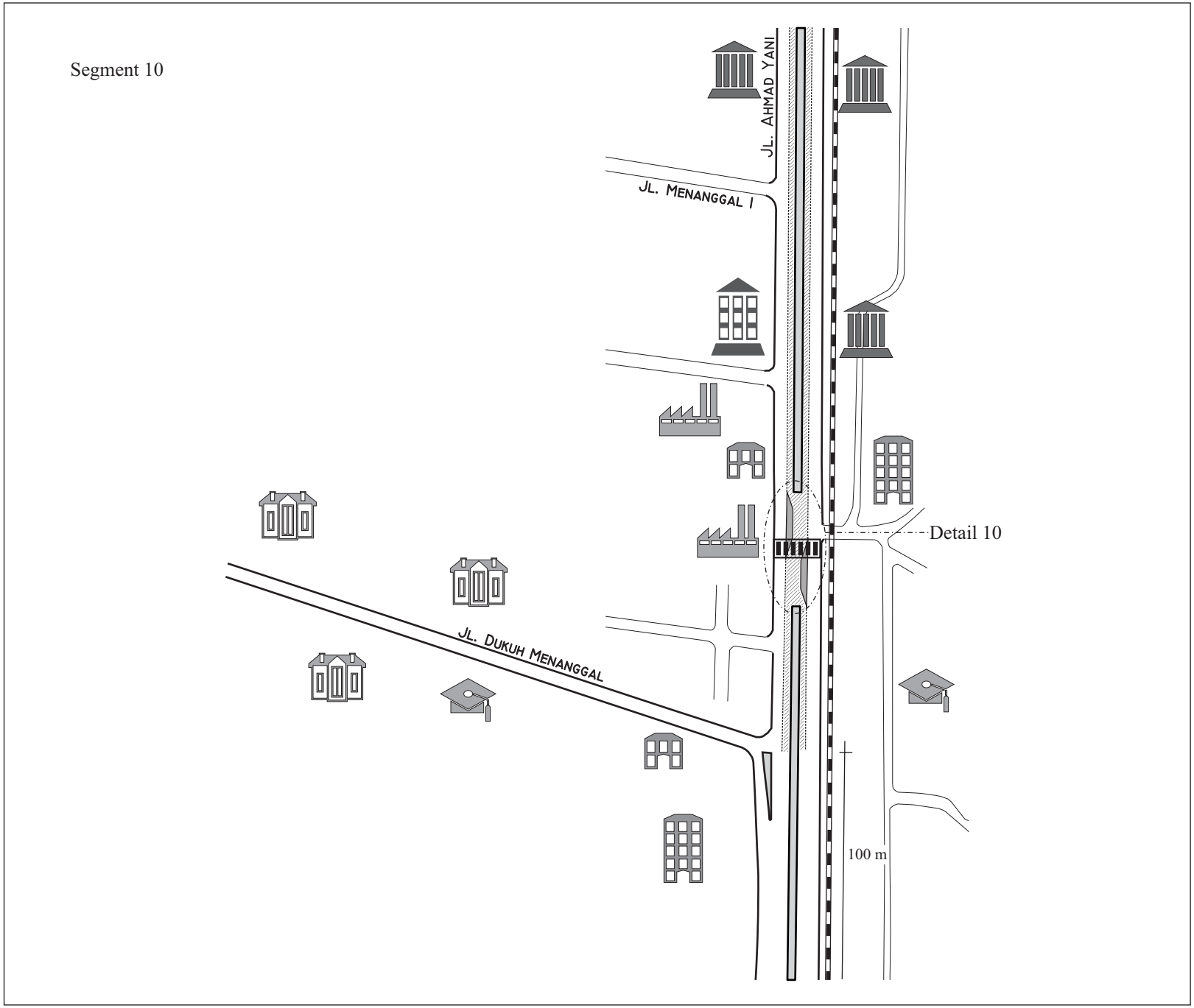
North

Non scaled

Road inventory by
Endri Sutjahjo
Jan 2001

Edited by
Frank Kraatz

With flow bus lane



Suggested Bus priority measures at Jl. A.Yani

Overview of With flow option

Segment 10 of 11 in North - South direction

North

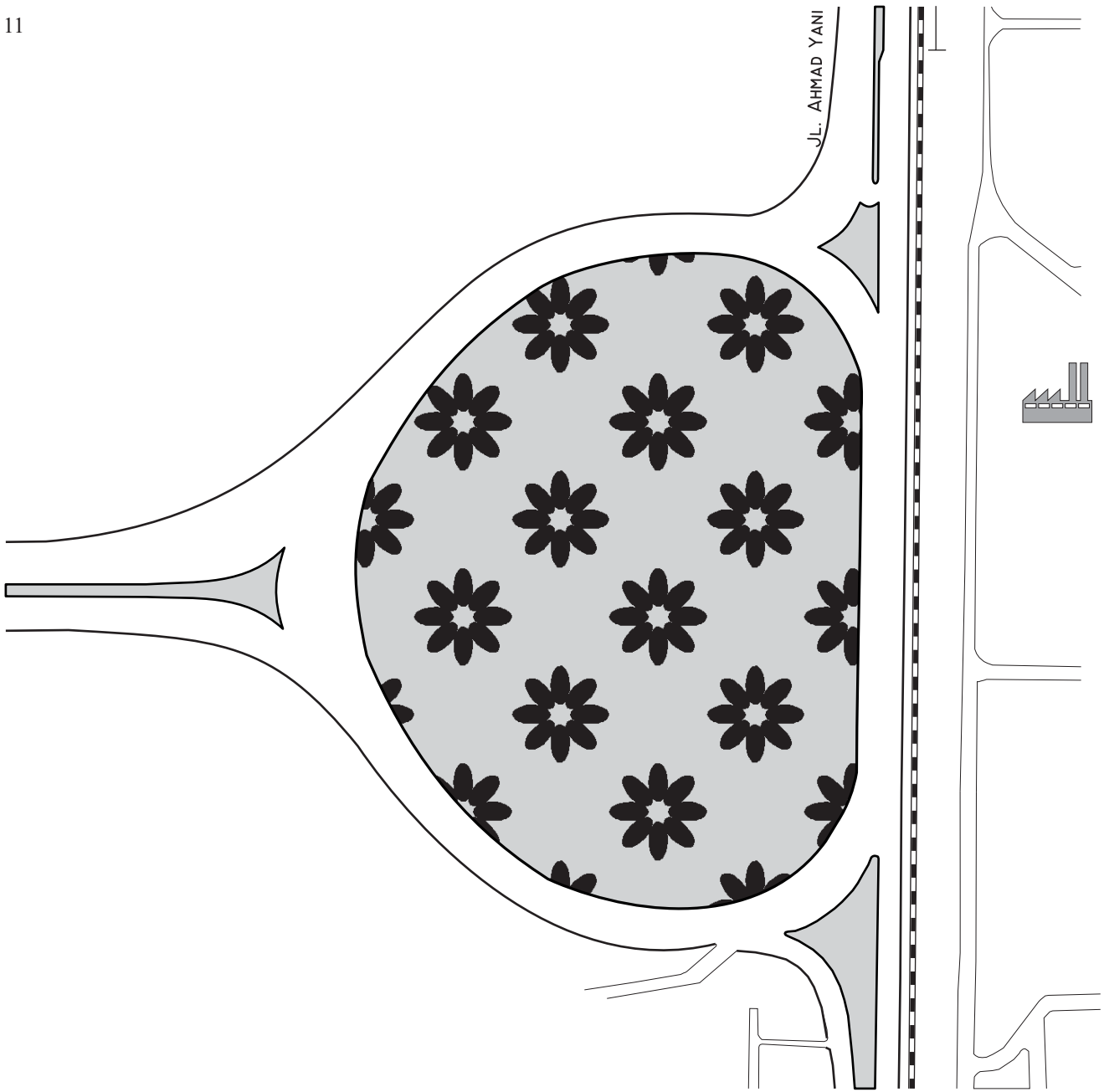
Non scaled

Road inventory by Endri Sutjahjo Jan 2001

Edited by Frank Kraatz

With flow bus lane

Segment 11



Suggested Bus priority measures at Jl. A.Yani

Overview of With flow option

Segment 11 of 11 in North - South direction

North

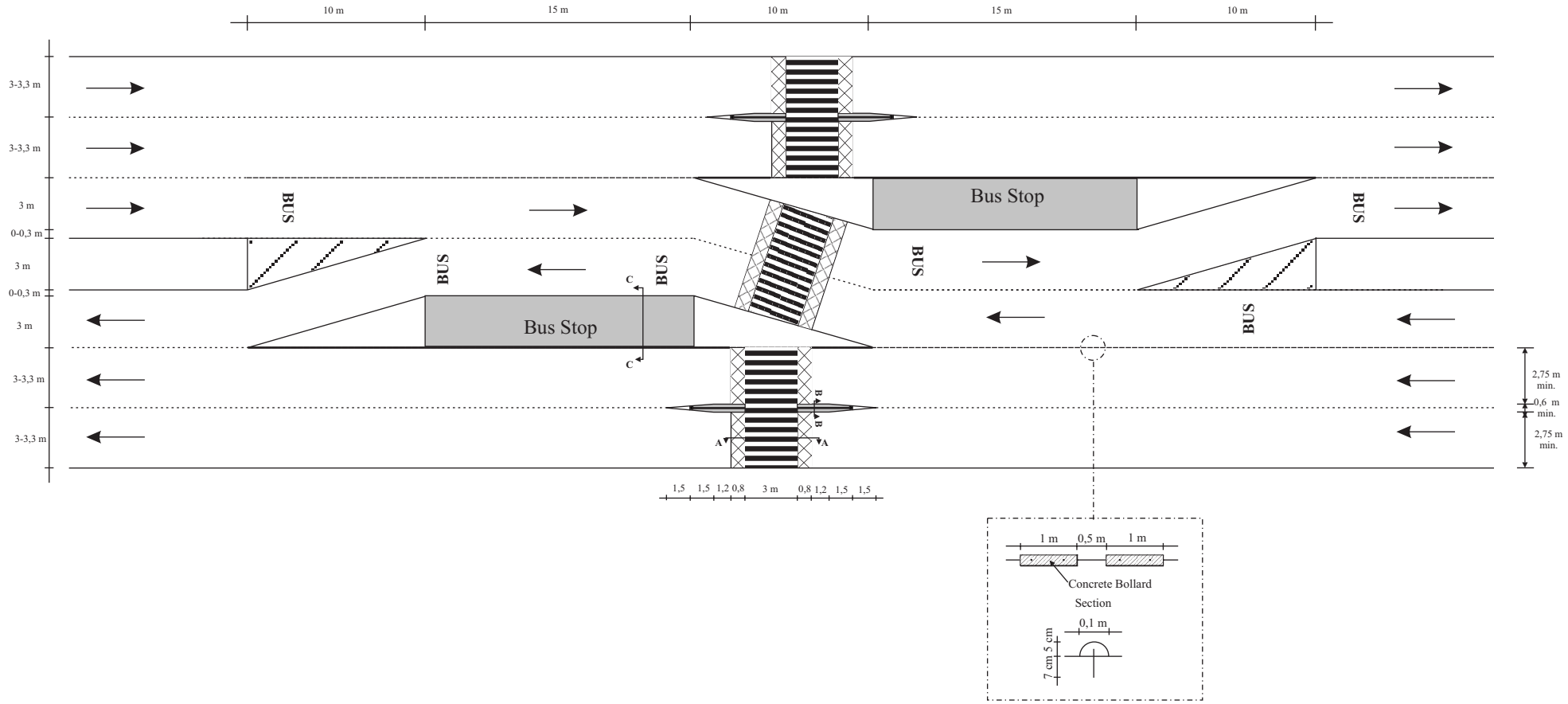
Non scaled

Road inventory by
Endri Sutjahjo
Jan 2001

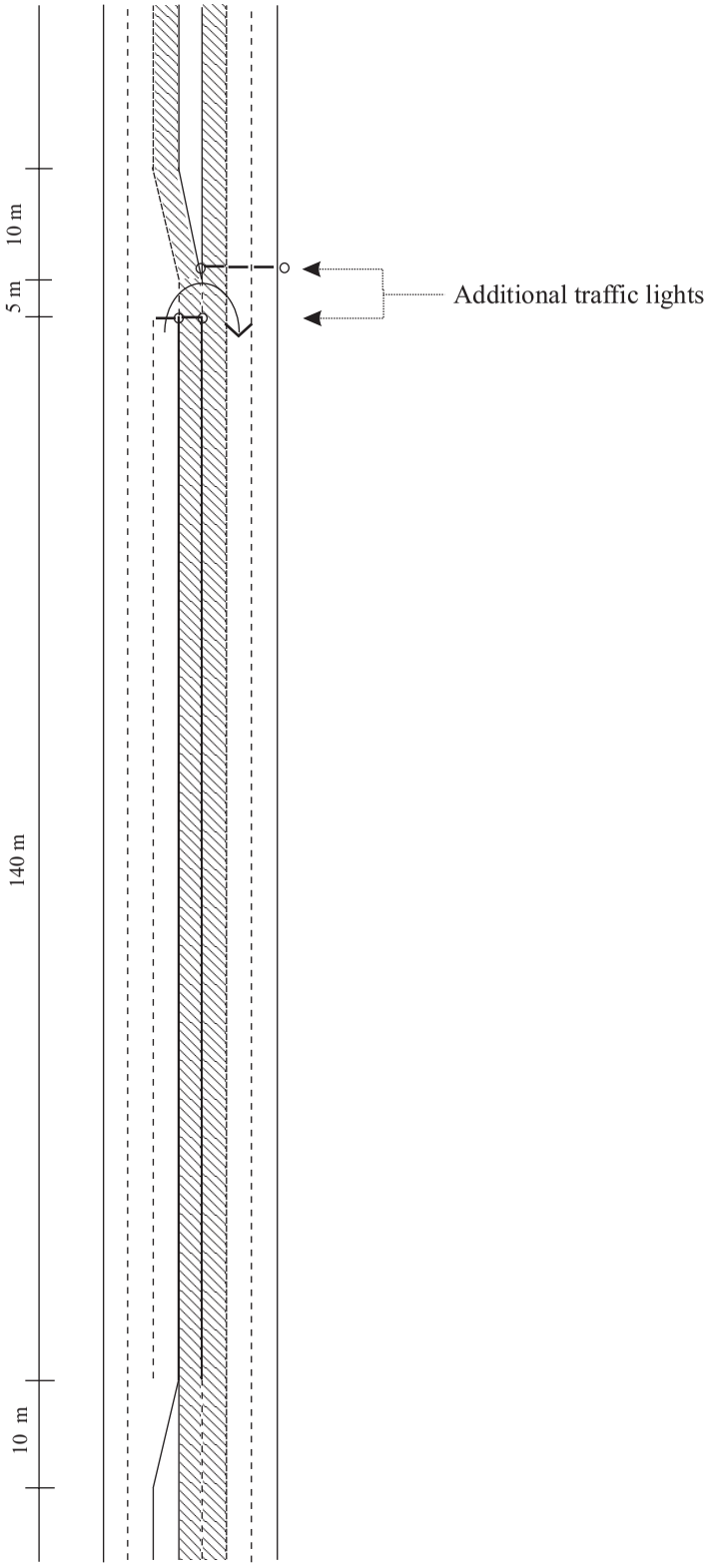
Edited by
Frank Kraatz

With flow bus lane

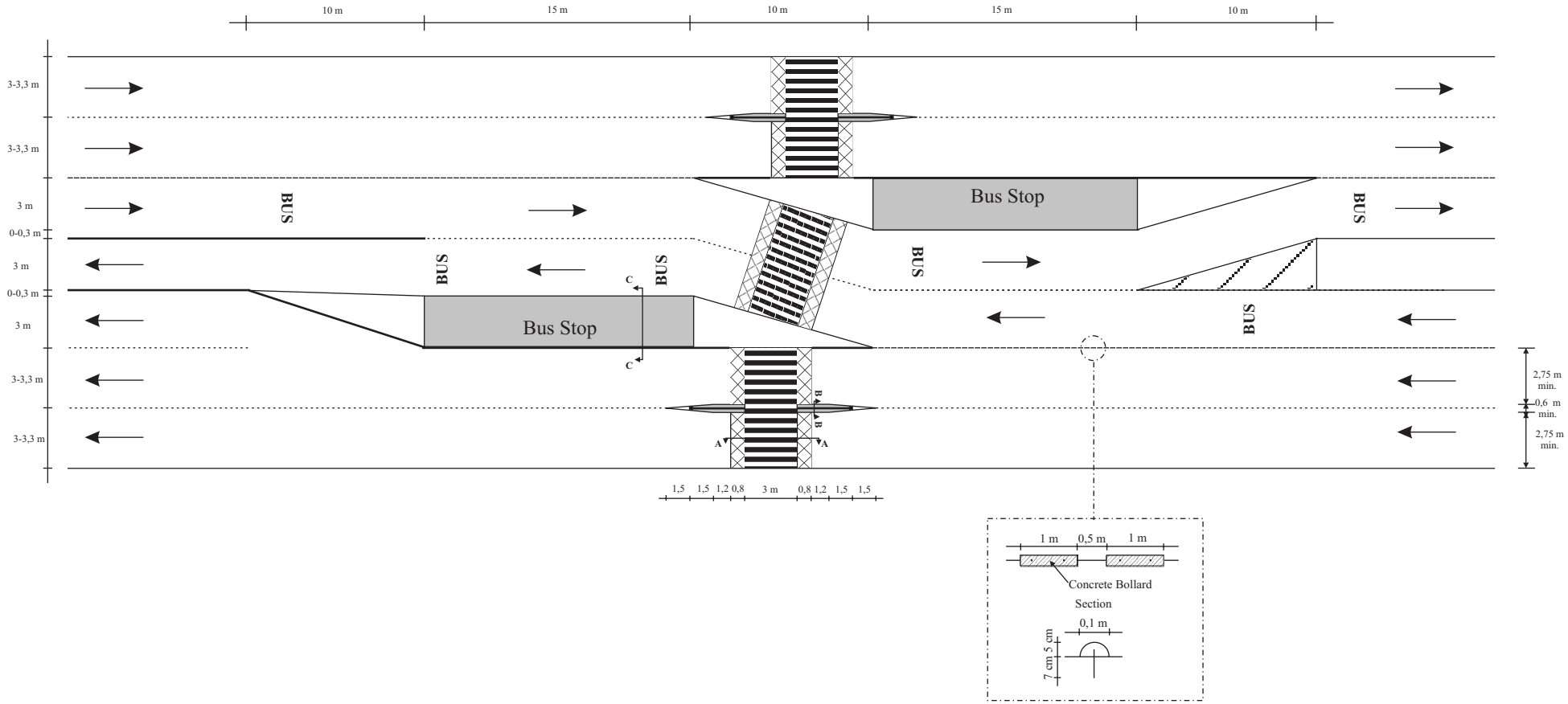
Detail 1


10 m
15 m
10 m
15 m
10 m
3-3,3 m
3-3,3 m
3 m
0-0,3 m
3 m
0-0,3 m
3 m
3-3,3 m
3-3,3 m
BUS
BUS
BUS
BUS
BUS
Bus Stop
Bus Stop
C
C
B
B
A
A
2,75 m min.
0,6 m min.
2,75 m min.
1,5 1,5 1,2 0,8 3 m 0,8 1,2 1,5 1,5
1 m 0,5 m 1 m
Concrete Bollard
Section
0,1 m
7 cm 5 cm

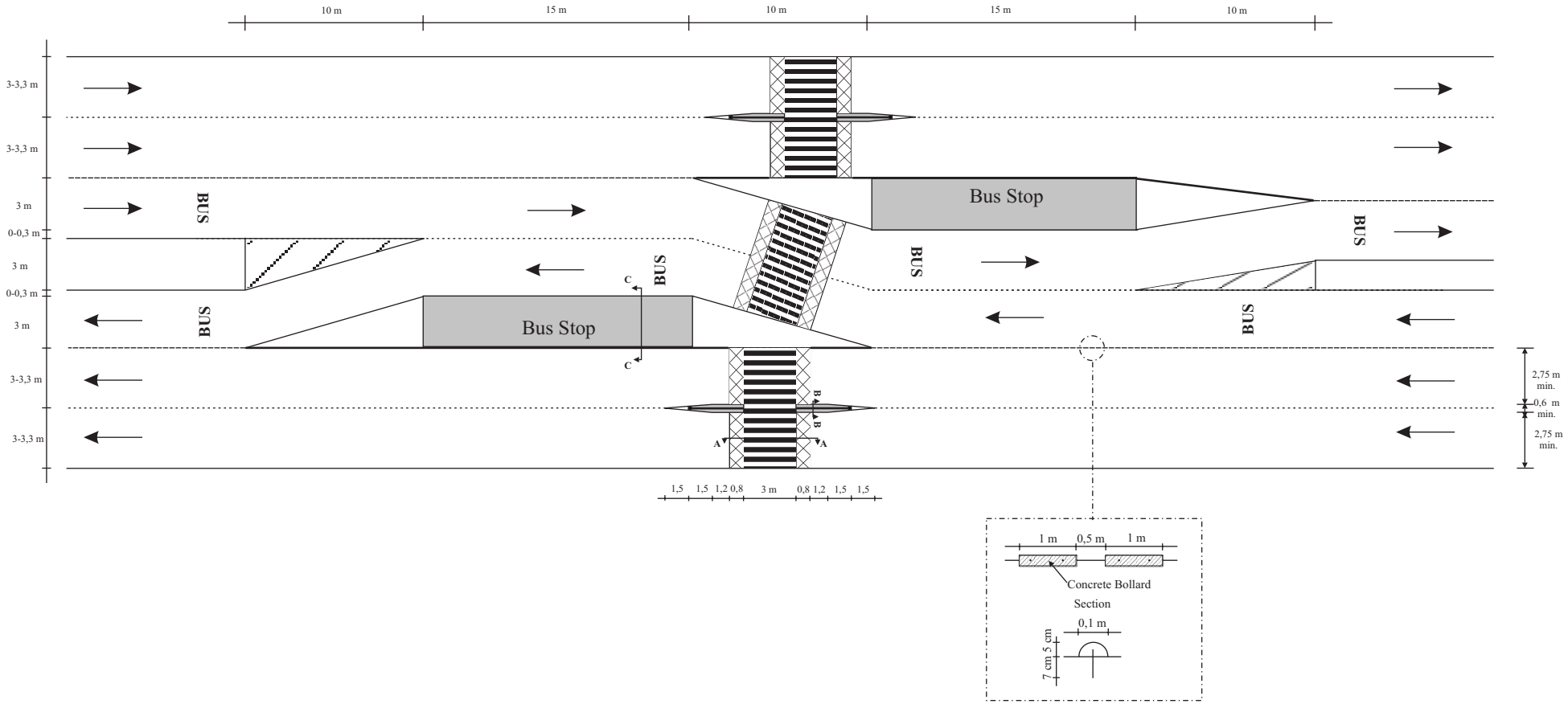
Detail 2


10 m
5 m
140 m
10 m
Additional traffic lights
With flow bus lane

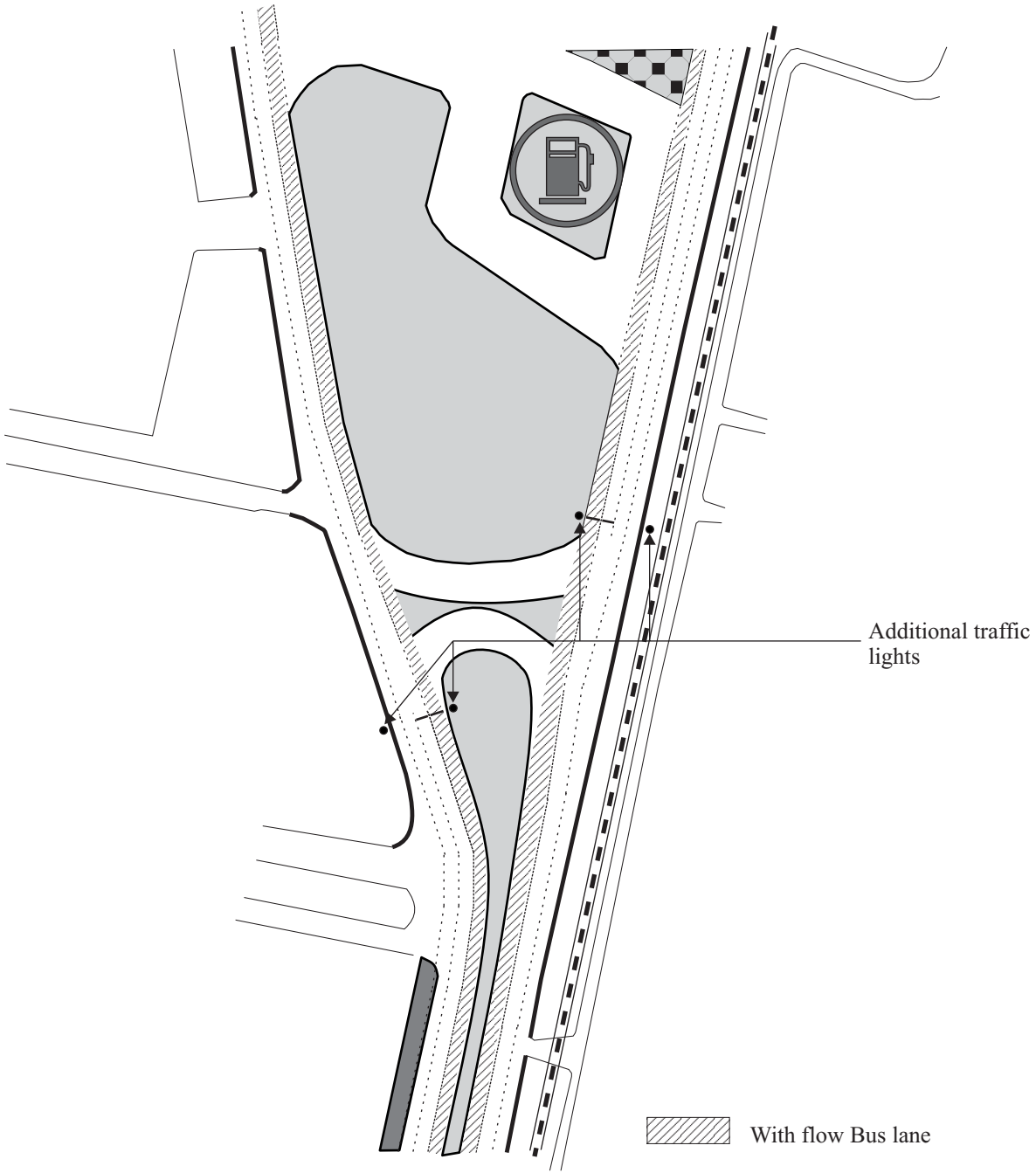
Detail 3


10 m
15 m
10 m
15 m
10 m
3-3,3 m
3-3,3 m
3 m
0-0,3 m
3 m
0-0,3 m
3 m
3-3,3 m
3-3,3 m
BUS
BUS
BUS
BUS
BUS
BUS
Bus Stop
Bus Stop
C
C
A
A
B
B
1,5 1,5 1,2 0,8 3 m 0,8 1,2 1,5 1,5
2,75 m min.
0,6 m min.
2,75 m min.
1 m 0,5 m 1 m
Concrete Bollard
Section
0,1 m
7 cm 5 cm

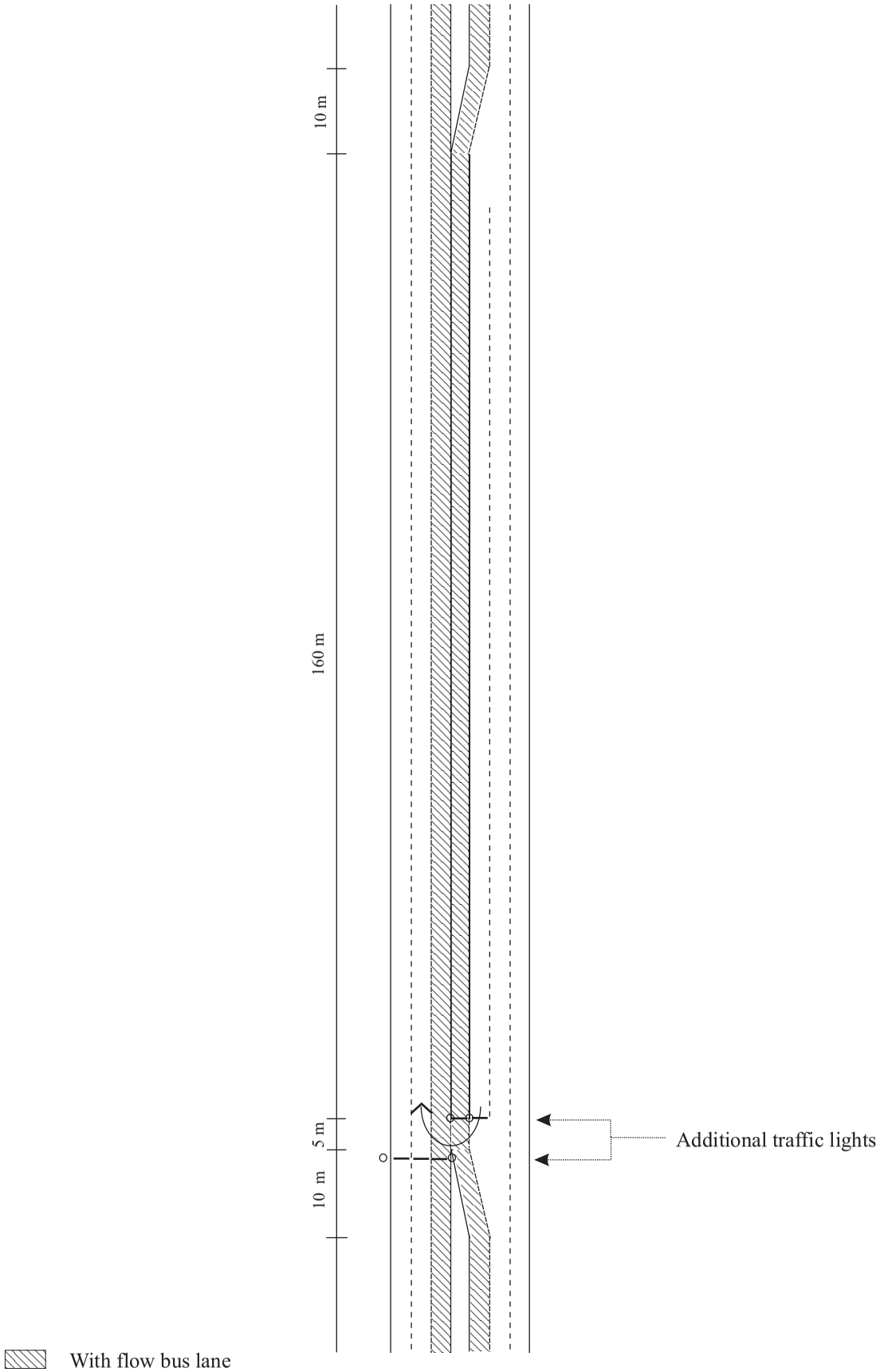
Detail 5


10 m
15 m
10 m
15 m
10 m
3-3,3 m
3-3,3 m
3 m
0-0,3 m
3 m
0-0,3 m
3 m
3-3,3 m
3-3,3 m
BUS
BUS
BUS
BUS
BUS
Bus Stop
Bus Stop
C
C
B
B
A
A
1,5 1,5 1,2 0,8 3 m 0,8 1,2 1,5 1,5
2,75 m min.
0,6 m min.
2,75 m min.
1 m 0,5 m 1 m
Concrete Bollard
Section
0,1 m
7 cm 5 cm

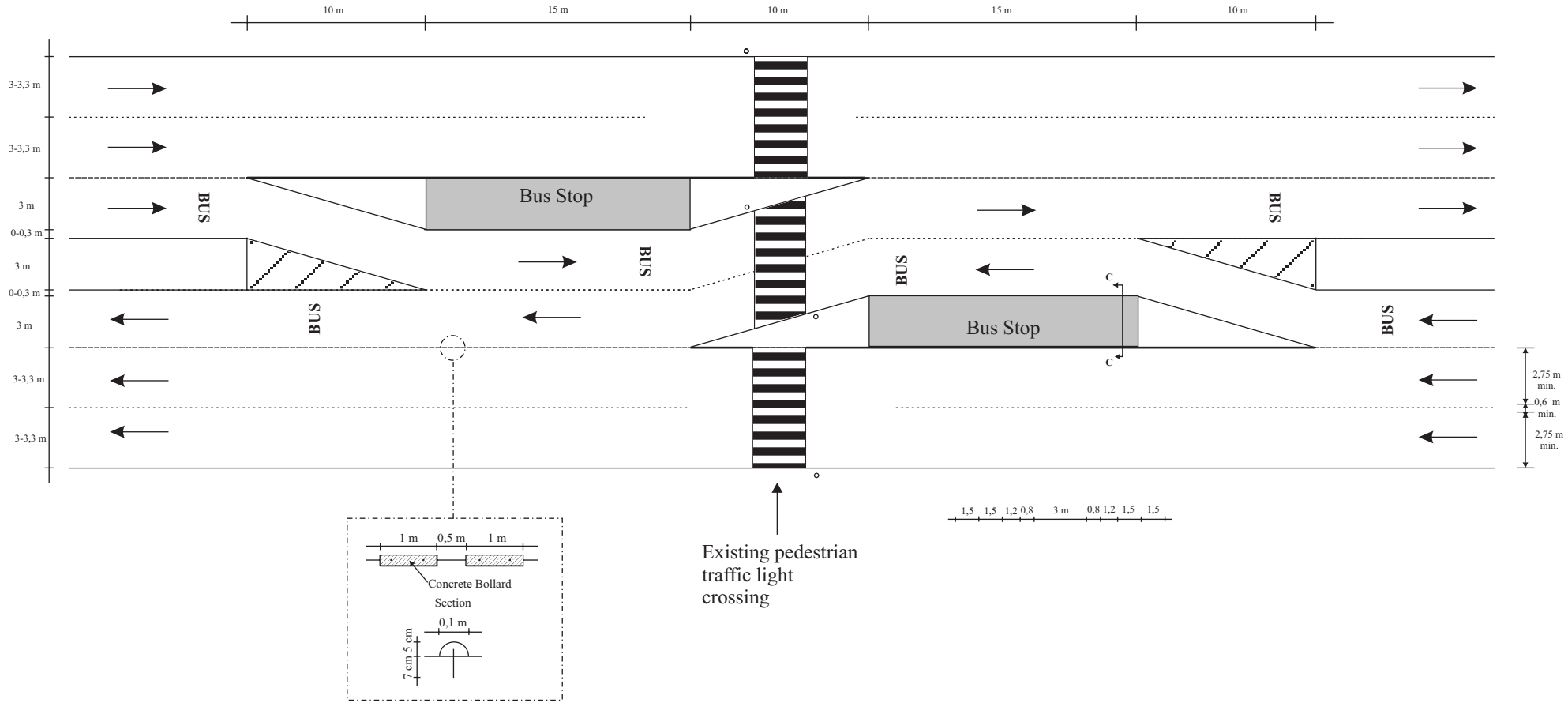
Detail 6



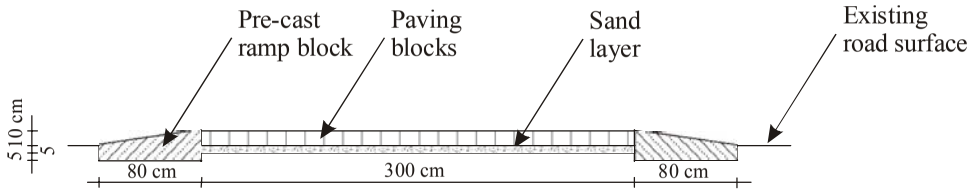
Detail 8


10 m
160 m
5 m
10 m
Additional traffic lights
With flow bus lane

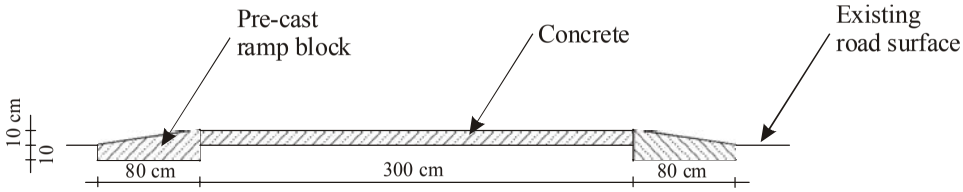
Detail 9


10 m
15 m
10 m
15 m
10 m
3-3,3 m
3-3,3 m
3 m
0-0,3 m
3 m
0-0,3 m
3 m
3-3,3 m
3-3,3 m
BUS
BUS
BUS
BUS
BUS
Bus Stop
Bus Stop
C
C
2,75 m min.
0,6 m min.
2,75 m min.
1,5 1,5 1,2 0,8 3 m 0,8 1,2 1,5 1,5
1 m 0,5 m 1 m
Concrete Bollard
Section
0,1 m
7 cm 5 cm
Existing pedestrian traffic light crossing

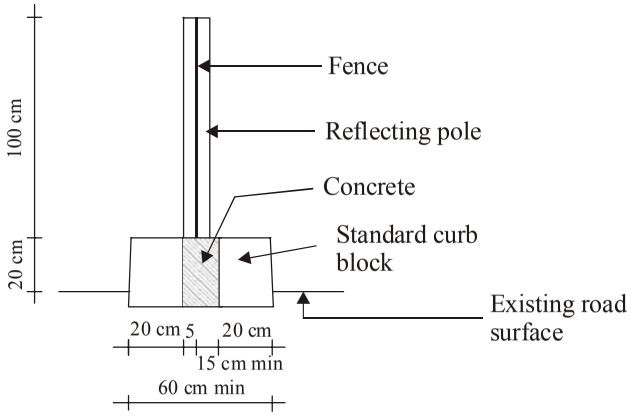
Section A - A zebra cross yang ditinggikan, versi A



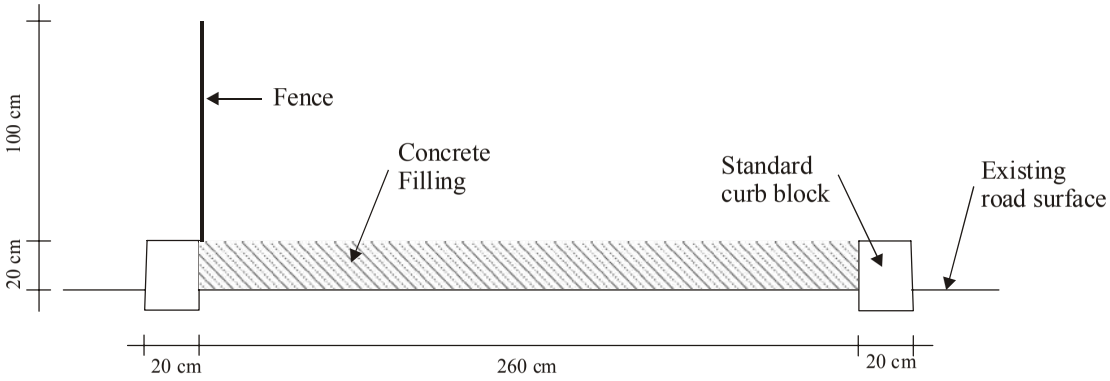
Section A - A zebra cross yang ditinggikan, versi B



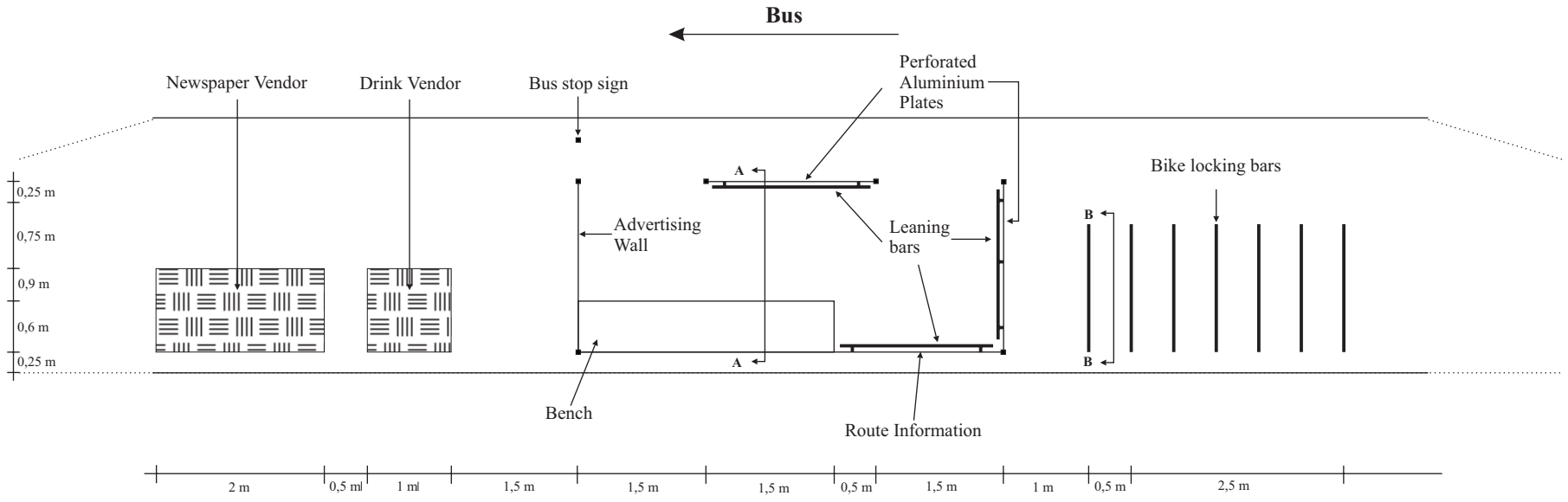
Section B-B pulau pejalan kaki



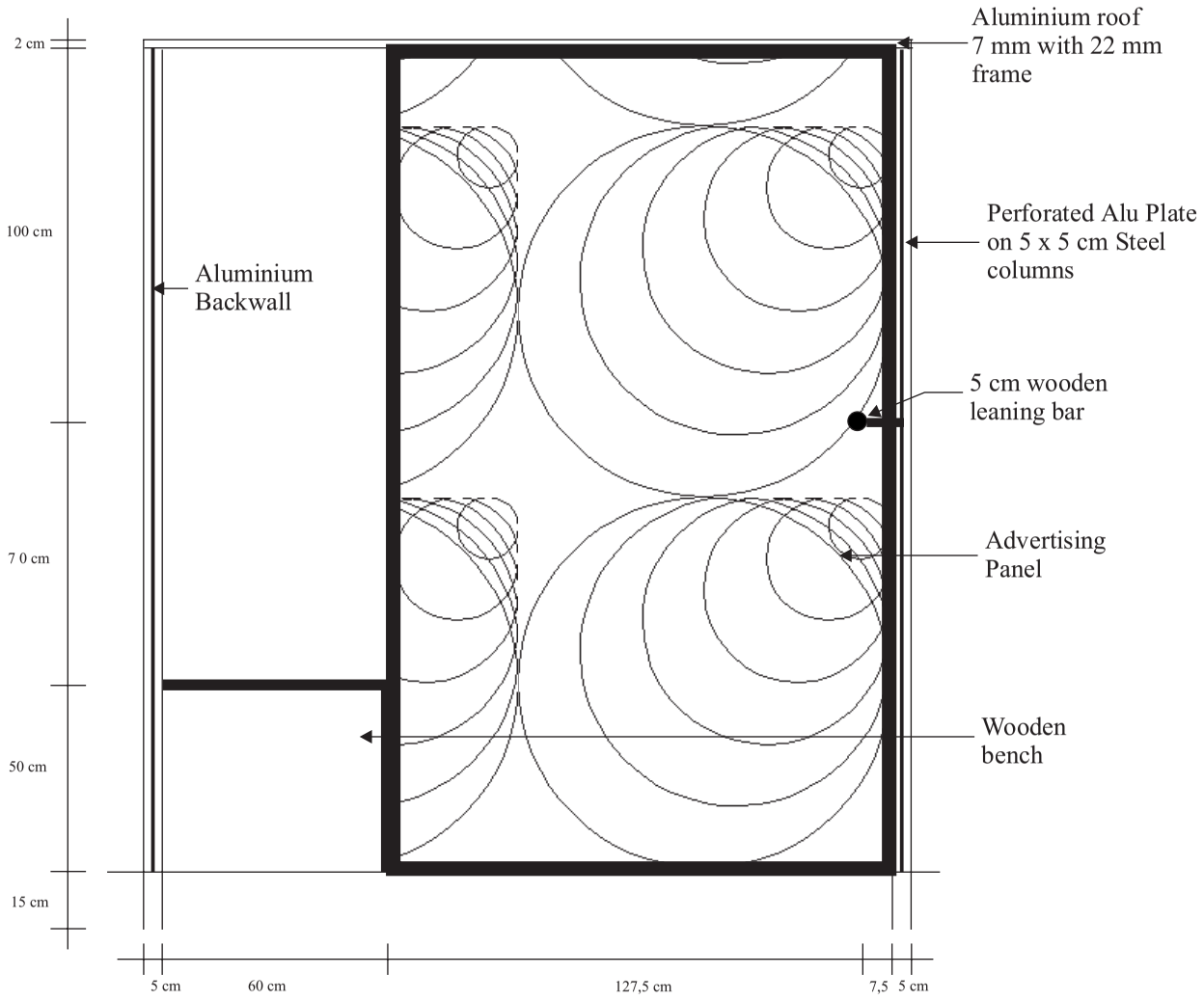
Section C-C of bus stop pad



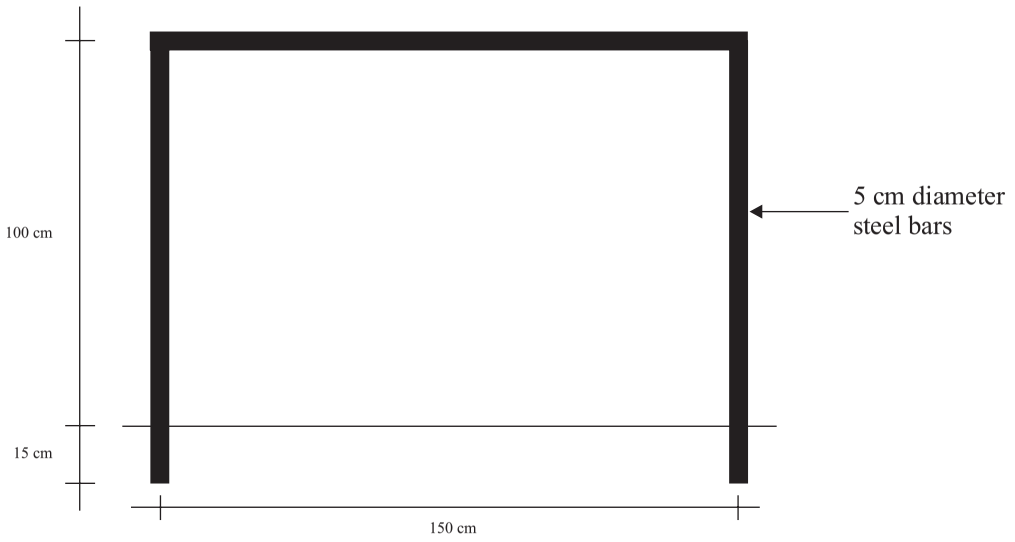
Layout of sheltered Bus Stop on with-flow Bus pad at A.Yani



Section A-A of bus stop shelter



Section B-B of Bike locking bars



11. PRELIMINARY COSTING

(See following pages.)

Preliminary cost estimation of bus priority measures at Jl. Ahmad Yani

Median on-line bus lane

Approx. Vol.	Work description	Cost per unit [1000 Rp.]	Total cost [1000 Rp.]
	Detail 1		
54 m³	Breaking up of existing median	50	2700
180 m²	Build up new road structure at former median	100	18000
102 m	Set curbs 10 cm width for pads	2	204
31 m³	Concrete filling K225	300	9300
10 m²	Thermoplastic paint (additional road mark.)	60	600
64 m	Set Fence	15	960
			31764
	Detail 2		
93 m³	Breaking up of existing median	50	4650
330 m²	Build up new road structure at former median	100	33000
78 m³	Earth digging for drainage construction	20	1550
155 m	Drainage ledges incl. Subconstruction	250	38750
280 m	Set curbs 10 cm width as physical divider	2	560
4 p.	Lamp box	800	3200
5 p.	Stop line	80	400
3 p.	short pole for traffic light	3500	10500
1 p.	curved pole for traffic light	4500	4500
1 p.	2 group local controller	30000	30000
			127110
	Detail 3		
54 m³	Breaking up of existing median	50	2700
120 m²	Build up new road structure at former median	100	12000
30 m³	Earth digging for drainage construction	20	600
60 m	Drainage ledges incl. Subconstruction	250	15000
102 m	Set curbs 10 cm width for pads	2	204
23 m³	Concrete filling K225	300	6900
10 m²	Thermoplastic paint (additional road mark.)	60	600
64 m	Set Fence	15	960
			38964
	Detail 4		
54 m³	Breaking up of existing median	50	2700
120 m²	Build up new road structure at former median	100	12000
30 m³	Earth digging for drainage construction	20	600
60 m	Drainage ledges incl. Subconstruction	250	15000
102 m	Set curbs 10 cm width for pads	2	204
23 m³	Concrete filling K225	300	6900
10 m²	Thermoplastic paint (additional road mark.)	60	600
64 m	Set Fence	15	960
			38964

Preliminary cost estimation of bus priority measures at Jl. Ahmad Yani

Median on-line bus lane

Approx. Vol.	Work description	Cost per unit [1000 Rp.]	Total cost [1000 Rp.]
	Detail 5		
54 m³	Breaking up of existing median	50	2700
120 m²	Build up new road structure at former median	100	12000
30 m³	Earth digging for drainage construction	20	600
60 m	Drainage ledges incl. Subconstruction	250	15000
102 m	Set curbs 10 cm width for pads	2	204
23 m³	Concrete filling K225	300	6900
10 m²	Thermoplastic paint (additional road mark.)	60	600
64 m	Set Fence	15	960
			38964
	Detail 8		
5 m³	Breaking up of existing u-turn construction	50	250
98 m³	Earth digging at road side	20	1960
147 m²	Build up new road structure	100	14700
4 p.	Lamp box	800	3200
4 p.	Stop line	80	320
2 p.	short pole for traffic light	3500	7000
2 p.	curved pole for traffic light	4500	9000
1 p.	2 group local controller	30000	30000
105 m²	Thermoplastic paint (Road markings)	60	6300
			72730
	Detail 7		
54 m³	Breaking up of existing median	50	2700
120 m²	Build up new road structure at former median	100	12000
30 m³	Earth digging for drainage construction	20	600
60 m	Drainage ledges incl. Subconstruction	250	15000
102 m	Set curbs 10 cm width for pads	2	204
23 m³	Concrete filling K225	300	6900
10 m²	Thermoplastic paint (additional road mark.)	60	600
64 m	Set Fence	15	960
			38964
	Detail 8		
105 m³	Breaking up of existing median	50	5250
350 m²	Build up new road structure at former median	100	35000
88 m³	Earth digging for drainage construction	20	1750
175 m	Drainage ledges incl. Subconstruction	250	43750
320 m	Set curbs 10 cm width as physical divider	2	640
4 p.	Lamp box	800	3200
5 p.	Stop line	80	400
3 p.	short pole for traffic light	3500	10500
1 p.	curved pole for traffic light	4500	4500
1 p.	2 group local controller	30000	30000
			134990

Preliminary cost estimation of bus priority measures at Jl. Ahmad Yani

Median on-line bus lane

Approx. Vol.	Work description	Cost per unit [1000 Rp.]	Total cost [1000 Rp.]
	Detail 9		
54 m³	Breaking up of existing median	50	2700
120 m²	Build up new road structure at former median	100	12000
30 m³	Earth digging for drainage construction	20	600
60 m	Drainage ledges incl. Subconstruction	250	15000
102 m	Set curbs 10 cm width for pads	2	204
23 m³	Concrete filling K225	300	6900
10 m²	Thermoplastic paint (additional road mark.)	60	600
64 m	Set Fence	15	960
			38964
	Detail 10		
54 m³	Breaking up of existing median	50	2700
120 m²	Build up new road structure at former median	100	12000
30 m³	Earth digging for drainage construction	20	600
60 m	Drainage ledges incl. Subconstruction	250	15000
102 m	Set curbs 10 cm width for pads	2	204
23 m³	Concrete filling K225	300	6900
10 m²	Thermoplastic paint (additional road mark.)	60	600
64 m	Set Fence	15	960
			38964
	Raised Zebra (Pedestrian crossings) Version A		
7 m³	Breaking up of existing road structure	50	350
40 m	Set precast ramp blocks	36	1440
60 m²	Set paving blocks on compacted sand layer	36	2160
28 m	Set standard curb blocks	2.5	70
0.3 m³	Place concrete filling	300	90
4 p.	Set reflecting pole	350	1400
28 m	Set Fence	15	420
4 p.	Set zebra crossing and bump warning signs	750	3000
32 m²	Paint zebra and pavement marking	57	1824
6 month	Attendant	300	1800
			12554
	Raised Zebra (Pedestrian crossings) Version B		
4 m³	Breaking up of existing road structure	50	200
40 m	Set precast ramp blocks	36	1440
6.3 m³	Place concrete pavement + filling	300	1890
28 m	Set standard curb blocks	2.5	70
4 p.	Set reflecting pole	350	1400
28 m	Set Fence	15	420
4 p.	Set zebra crossing and bump warning signs	750	3000
32 m²	Paint zebra and pavement marking	57	1824
6 month	Attendant	300	1800
			12044

Preliminary cost estimation of bus priority measures at Jl. Ahmad Yani

Median on-line bus lane

Approx. Vol.	Work description	Cost per unit [1000 Rp.]	Total cost [1000 Rp.]
	Station layout		
6 p.	Steel colums	100	600
15 m²	Aluminium Back and Advertising Wall	65	1001
9 m²	Perforated Aluminium Plates	70	616
10 m²	Aluminium Roof 7mm with 22 mm frame	250	2500
1 p.	Wooden bench	150	150
6 m	Wooden Leaning Bars	10	60
7 p.	Bike locking/leaning bars	150	1050
1 p.	Bus stop sign	500	500
			6477
	Additional costs on odd and even car restriction		
4 p.	Over road signs: car restriction	1000	4000
8 p.	Curved pole	4500	36000
4 p.	Short pole	3500	14000
18 p.	Warning signs: car restriction ahead	500	9000
18 p.	Curved pole	4500	81000
			144000
	General		
400 m²	Lane line (thermoplastic paint)	60	24000
150 m²	Bus written on lane ev. 200 m	60	9000
9000 m	Set physical divider bollards	2	18000
1 p.	Tearing down of existing pedestrian bridge	20000	20000
6 p.	Raised Zebra (Pedestrian crossing)	12044	72264
14 p.	Station layout	6477	90678
1 p.	Odd and even Car restriction	144000	144000
			377942
Total cost of with flow option			**978320**