

CHALLENGES IN THE DESIGN OF MOTORWAY INGRESS / EGRESS TO STORMWATER MANAGEMENT AND ROAD TUNNEL (SMART)

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ABSTRACT

This paper gives an insight into the design of an underground roadway connecting to the stormwater tunnel which also double as a road tunnel.

The design for the North Ingress / Egress and South Ingress / Egress may be similar in procedure to achieve the end product and objective but the site constraints and developments which are different at the North Ingress / Egress and the South Ingress / Egress present different challenges to the design engineer.

A step by step analysis procedure and evaluation of the site constraints leading to the decision stage and final design is presented.

1.0 INTRODUCTION

The Stormwater Management and Road Tunnel (SMART) project consists of a motorway, which is formed by the following elements:

- (a) A double deck structure within the bypass tunnel (a length of about 3 km)
- (b) Ingress and Egress connection links at the northern end of the double deck structure to the Jalan Sultan Ismail extension and Jalan Tun Razak, and at the southern end of the double deck structure to the KL-Seremban highway.

This 3 km stretch of tunnel although primarily used for stormwater is usefully utilised as a road tunnel to relieve the traffic congestion in Jalan Sungai Besi and Jalan Yew. Conceptual layouts of the tunnel are shown in **Figure 1** and **Figure 2**.

2.0 DESIGN BRIEF

2.1 Design Standards

The Ingress / Egress road alignments are designed in accordance with the current Malaysian Standards and British Standards, as follows:

- (i) Design Standards for the Interurban Toll Expressway Systems of Malaysia : MHA (1986).
- (ii) Flexible Pavement Design Manual, JKR Arahan Teknik (Jalan) No. 5/85.
- (iii) A Guide on Geometric Design of Roads, JKR Arahan Teknik (Jalan) No. 8/86.

2.1 Design Standards - (Cont'd)

- (iv) REAM-GL 2/2002 - A Guide on Geometric Design of Roads.
- (v) Manual on Design Guidelines for Longitudinal Traffic Barrier, JKR Arahan Teknik (Jalan No.1/85.
- (vi) Arahan Teknik (Jalan) 12/87 : A Guide to the Design of Interchanges.
- (vii) Arahan Teknik (Jalan) 11/87 : A Guide to the Design of At-Grade Intersection.
- (viii) JKR Standards for Traffic Control Devices, Directional Signs and Road Markings : JKR (2A/85, 2B/85, 2C/85, 2D/85 and 2E/17).
- (ix) Guide to Landscape Development on Urban and Interurban Highways. Design Standards.
- (x) BD 78/99 - Design of Road Tunnels, U.K. Department of Transport (Highway Agency).
- (xi) DMRB 6.1.1 - Highway Link Design, U.K. Department of Transport (Highway Agency).
- (xii) DMRB 6.1.2 - Cross Sections and Headroom, U.K. Department of Transport (Highway Agency).

2.2 Geometric Standards

The Ingress and Egress tunnel alignments are generally designed to JKR Class U4 up to a maximum design speed of 60 km/h. The table below shows the geometric standards adopted:

Elements of Design	Criteria
Design Standard	U4
Design Speed	60 km/h 50 km/h (at constraint area)
Stopping Sight Distance	85 m
Minimum Radius - Absolute	150 m 136 m (at constraint area)
Minimum Length of Spiral	35 m
Maximum Super elevation	2.5% (Tunnel)
Maximum Grade - Desirable	5%
Maximum Grade	8%
Crest Vertical Curve (k) - Desirable	15
Crest Vertical Curve (k) - Absolute	10
Sag Vertical Curve (k) - Desirable	15
Sag Vertical Curve (k) - Absolute	12

2.3 Cross-Section Standards

(a)	Lane Width (Single Lane Traffic Flow) (Two Lane Traffic Flow) (Multiple Traffic Flow)	5.0 m 3.35 m 3.50 m
(b)	Emergency Lane (LHS)	2.0 m
(c)	Marginal Strip Width (RHS)	0.5 m
(d)	M&E Corridor Width (Single Lane traffic Flow) (Two Lane Traffic Flow)	0.8 m 0.5 m
(e)	Traffic Envelope Vertical Height Clearance	2.55 m
(f)	Kerbed Shoulder Width	1.5 m

2.4 Permitted Vehicle

The tunnels are designed only for light vehicles i.e. Class 1 vehicles having two (2) axles and four (4) wheels and not exceeding 2.1 m height. Other vehicle types inclusive of motorcycles will not be permitted to use the motorway.

2.5 Pavement

Two (2) types of pavement are used for the Ingress / Egress.

- (i) Concrete Pavements are provided to ensure the pavements are maintenance friendly during the operation of the motorway system. The concrete pavements are designed to a design life of forty (40) years.
- (ii) Flexible pavement is provided at the at-grade road with bituminous surfacing designed for overlays at seven (7) years interval and the unbound pavement layers for twenty (20) years.

2.6 Safety Barriers

Longitudinal safety barriers in the form of New Jersey concrete barriers are provided on all verges and along the median. Safety barriers are also provided on the top of U-Trough wall for the safety of the at-grade road traffics.

3.0 DESIGN CHALLENGES

The design for the North Ingress / Egress and South Ingress / Egress may be similar in procedure to achieve the end product and objective but the site constraints and developments which are different at the North Ingress / Egress and the South Ingress / Egress present different challenges to the design engineer.

For the North Ingress / Egress, the design challenges are related to finding the ingress / egress route through the structural constraints located underground.

For the South Ingress / Egress, the need to provide and maintain the directional traffic flow for both the ingress / egress and the existing at-grade roadways present a different design challenge.

The design challenges for the North Ingress / Egress and South Ingress / Egress are presented separately:

3.1 North Ingress / Egress

3.1.1 Data Collection

In any project, the most fundamental task is data collection. Data collected provides valuable information to assist the designer to come out with an appropriate design solution - *“Do it right the first time”* should be the objective of the designer to cut down unnecessary loss of time and to prevent abortive works.

Data collection includes:

- (i) Site Reconnaissance - A site reconnaissance will assist one to see and understand the real condition in the project area. The site captured in the mind and complemented with site photographs help to provide a lasting impression for the design.

3.1.1 Data Collection - (Cont'd)

- (ii) Topographical Survey - The ground survey carried out to record the ground levels and natural terrain features such as water courses, ground conditions, vegetation and man-made amenities like buildings, roads, drains, culverts, TNB lines, Telekom lines, pylons, etc.
- (iii) Underground Utility Detection - To detect any utilities located underground like TNB power cables, Telekom lines, water pipes, sewer lines, etc.
- (iv) Soil Investigation - Carry out deep field boreholes, soil samplings, and soil tests and determine ground water tables to determine the soil conditions and soil strata.
- (v) Land Use and Land Ownership.

3.1.2 Check Data

Upon completion of data collection, the data are checked and reviewed to ensure the correctness and accuracy of the data.

For the topographical survey plans completed, site reconciliation are carried out to check the accuracy of the survey works and to ensure that existing features are not inadvertently left out.

Existing drainage system in the locality is properly recorded to ensure the continued operation of the drainage system after the completion of the project. Flood levels are calculated and checked for accuracy.

Utilities underground and overhead are checked with the Authorities concerned for correct connection.

3.1.2 Check Data - (Cont'd)

Discussions and meetings with relevant Authorities like DBKL, JKR, MHA and JPS are also undertaken to check on any future planned developments in the project area concerned. These information are incorporated and taken into consideration in the design for clash analysis.

3.1.3 Weigh and Decide

All data collected and satisfactorily checked are disseminated into one (1) drawing to provide an overall indication on the level of difficulty of the site with respect to design constraint and construction.

From topographical survey, any natural terrain features and man-made amenities that are affected by the project are to be reviewed thoroughly for demolition, reinstatement and / or relocation.

For utility services located above ground and below ground and in the way of the project, relocation of the utility services would need to be carried out. A study would need to be carried out to determine the alternative routes for the services. The proposal for the relocation of the services would be submitted to the relevant Authorities concerned for approval. Where necessary, follow-up and co-ordination meetings with the Authorities will help speed up the approval process.

From deep field borings, soil samplings and soil tests, the structural strength of the ground strata can be determined. These information will help to guide the designer on the type of structures to be adopted and in particular the appropriate type of foundation required.

3.1.3 Weigh and Decide - (Cont'd)

Information on land use and land ownership may also affect the design decision when land acquisition is concerned. Land acquisition of private properties can be time-consuming due to objections to the acquisition. Delay in land acquisition may also cause delay in project completion.

From discussions and meetings with the relevant Authorities, information gathered on oncoming and future developments in the project area are also considered in the planning and design of the North Ingress / Egress motorway.

Two (2) other highway projects were also in the planning and design stages. The first project is the Jalan Sultan Ismail to Jalan Kampung Pandan Link Highway via Kampung Pandan Roundabout under DBKL and the second project is the Kuala Lumpur - Putrajaya Dedicated Highway under Lembaga Lebuhraya Malaysia commencing from the Kampung Pandan Roundabout.

The Link Highway will cross over the Kampung Pandan Roundabout at the third tier while the Dedicated Highway which commence at the Kampung Pandan Roundabout will be connected to the existing roundabout overpass bridge at the second tier. The impact of the three (3) projects at the Kampung Pandan Roundabout will require discussions, co-ordinations and horse-trading to achieve a win-win solution for all the three (3) projects.

3.1.4 Design Action

Following the “*weigh and decide*” stage, the design of the horizontal alignment for the North Ingress / Egress can commence. The locations of the piers and pile foundations of the existing overpass bridge at the Kampung Pandan Roundabout are physical constraints below the ground level. The designer will search for available spaces to navigate the horizontal alignment from the tunnel to the ingress / egress point.

3.1.4 Design Action - (Cont'd)

The plans from the proposed Link Highway and the Dedicated Highway are superimposed onto the designed horizontal alignment of the North Ingress / Egress for clash analysis and follow-up discussions with the other two (2) parties concerned to reach an agreement on the design and the timing of the construction at the point of interest to both parties.

The design layout of the North Ingress / Egress is shown in **Figure 3**. **Photo 1** shows the North Ingress / Egress near the Kampung Pandan Roundabout.

3.2 South Ingress / Egress

The task carried out for the South Ingress / Egress motorway follows the same procedure of the North Ingress / Egress motorway except that there are no developments in the area to complicate the design. However, the designer is confronted with a new design challenge to reconfigure the traffic lanes of the existing four-leg Salak Interchange to maintain the same directional traffic flow for the at-grade non-toll traffic as well as for the South Ingress / Egress motorway.

The Salak Interchange was originally a clover leaf interchange. The interchange was later upgraded and one of its quadrant was replaced with a directional ramp to improve the capacity of the interchange. The Salak Interchange allows all directional traffic flow from the four legs of the interchange.

With the introduction of the South Ingress / Egress motorway, weaving problem along the KL - Seremban Highway leg of the interchange will arise. This will inevitably affect the capacity of the Salak Interchange, in particular the city bound traffic along the Seremban - KL route. Enhancements of the Salak Interchange in conjunction with the South Ingress / Egress are required. The objective of the design is to remove weaving traffic from interrupting the mainline flows from and to the city by segregating the city-bound mainline traffic from other traffic and provision of additional lanes at the Salak Interchange to achieve the objective. A layout plan of the South Ingress / Egress and the enhancement of the Salak Interchange are shown in **Figure 4**. **Photo 2** shows the South Ingress / Egress motorway.

4.0 CONCLUSION

The SMART Project has been successfully implemented and fully operational. The design procedure adopted for the North Ingress / Egress and South Ingress / Egress motorway have shown that with proper data collection, data evaluation, design consideration and co-ordination, all difficulties and challenges faced by designer can be minimised or overcome.