## 3.2 Comparison and Evaluation of Alternatives

For the purpose of comparison of each alternative, these criteria are taken into account in descending order as:-

(i) Land Availability
(ii) Impact on the Social Environment
(iii) Future Traffic Demand
(iv) Construction Economy
(v) Road User Benefits
(vi) Development Impact

### (i) Land Availability

Well begun is half done. Once the right-of-way acquisition problems are solved in an early stage it may fairly be said that the urban road development is successfully completed in its major parts.

However, the right-of-way acquisition in urban area is one of the most difficult problems as the following sufferings are always associated with:-
- Vast amount of cost
- Influence to the social environment

### (ii) Impact on the Social Environment

Good social environment should be maintained otherwise the project road could not be acceptable to the public.

Community disruption such as disturbance of built-up area and resettlement of squatters is considered to be a serious suffering to the social environment.

When developing an urban road network, not only reducing traffic congestion but also promoting high amenity in an urban area are the main focus.

### (iii) Future Traffic Demand

The enhancement of functional road network to meet future traffic demand is one of the most practical solution to maintain an urban activity in a preferable level.

(iv) Construction Economy

Cheaper is better. However, the construction cost of project road is not always independent of the relevant infrastructures. Thus, due investment should be done to achieve the objectives of project road. Furthermore, the project viability is carefully examined to compute overall benefits generated from due investment.

Ease of construction and construction period are also important factors.

(v) Road User Benefits

In general, the following aspects are acceptable:-

(a) Shorter road has more advantages such as time saving, reducing vehicle operating cost and so forth;

(b) Sharper horizontal curve less 500m has significant higher rate of traffic accident; and

(c) Steeper downward slope more 4% also has higher rate on traffic accident.

(vi) Development Impact

An efficient road network can encourage urban activity to induce desirable economic growth through promoting residential, commercial, industrial, institutional and recreation development.

The comprehensive comparison and evaluation of each alternative are summarized in Tables 3.7 through 3.12.

The optimum routes for three project roads are proposed in Figure 3.6.

These optimum routes are combined with each segment which is deliberated on technical feasibility and sometimes selected among alternatives through its comparison and evaluation.

Table 3.7: Table 6.7 : Comparison and Evaluation of Alternatives in Sungai Midah Area (Segment A-3)

| Item \ Alternative | | Alternative I | Alternative IIa | Alternative IIb | Alternative III |
|---|---|---|---|---|---|
| Background | | The idea presented by the previous study of the northern section of Middle Ring Road II | Original Route : Running in different landuse and providing at-grade intersection | New Idea : The same route as AL-IIa but adopting viaduct scheme | New Idea : Running on the existing Jalan Cheras and Jalan Cendekiawan |
| Road Length (m) | Throughway | 5750 | 5180 | 5240 | 6150 |
| | Frontage Road | 2000 | 2000 | 2000 | 2650 |
| | Interchange Ramp | 800 | 800 | 800 | 2500 |
| Proposed Right-of-Way | | 40m (65%) : 60m (35%) | 40m (59%) : 60m (41%) | 40m (22%) : 60m (78%) | 40m (53%) : 60m (47%) |
| 1. Land availability | | It is necessary to acquire land in two built-up housing area and compensate for its properties. The land availability is quite limited<br>Bad | In order to avoid violating any physical constraints, horizontal and vertical alignment are designed within available land<br>Good | It is necessary to acquire a limited land for construction of piers and its foundation in some developed area. Except in these areas, the route runs within available land<br>Fair | The route runs on the existing R.O.W. of both Jalan Cheras and Jalan Cendekiawan to avoid violating developed area<br>Good |
| 2. Impact on Social Environment | | Large scale countermeasures are required to mitigate adverse effects such as public nuisance during construction, adverse aesthetic view by viaduct, noise and air pollution, and so forth<br>Bad | Anticipated heavy volume of middle to long trip traffic causes traffic congestion at planned at-grade intersection to deteriorate existing environment along the route<br>Poor | It is preferable that the route passes in between different landuse and an elevated road on viaduct be adopted to secure the existing environment<br>Good | Even if frontage road is provided to secure the existing function of Jalan Cendekiawan, it is inevitable to suffer some adverse effects to the environment from predicted enormous traffic<br>Poor |
| 3. Future Traffic Demand | | It is possible to manage the anticipated enormous traffic volume at a high service level and high speed as designated in functional road network<br>Good | It is impossible to deal with future traffic demand by at-grade intersection. The designated function of MRR II cannot be satisfied at all<br>Bad | It is possible to deal with anticipated heavy traffic in reasonable level<br>Fair | In order to cope with complicated traffic movements at two successive interchanges, it is necessary to mix traffic of both MRR-II and Jalan Cheras. These combined excessive traffic deteriorate the function of road, traffic safety and so forth<br>Poor |
| 4. Construction Economy | | Initial investment seems to be too big to appreciate a feasibility of project, even if the utilization of space beneath viaduct is considered<br>Cost Index = 2.81 Bad | The cost of this scheme is very cheap but it is impossible to be regarded as due investment<br>Cost Index = 0.42 N/A | Due investment is done. This investment will meet the scheme of MRR II and contribute to gain sufficient benefit<br>Cost Index = 1.00 Good | The cost of this scheme is modest but it cannot be considered as due investment<br>Cost Index = 0.76 N/A |
| 5. Road User Benefit | | Horizontal and vertical alignment are preferable to road users<br>Good | Expected traffic congestion decreases road users' benefits considerably<br>Poor | Though minimum values of design criteria are adopted for horizontal and vertical alignment, it is still possible to keep traffic safety<br>Fair | An at-grade intersection at Cheras Interchange will remain otherwise it is impossible to manage complicated traffic movements. Road users of both MRR-II and Jalan Cheras cannot get sufficient benefits but suffer considerable loss<br>Bad |
| 6. Development Impact | | Development impact may hardly be expected due to crossing built-up housing area<br>N/A | No significant impact on development is found because the present landuse along the route has already been established<br>N/A | No significant impact on development is found because the present landuse along the route has already been established<br>N/A | Some impact on development are found in undeveloped area along Jalan Cheras<br>Fair |
| Evaluation | | Step 1 : The scheme of AL-IIa and AL-III cannot manage anticipated enormous traffic volume. Even if one of these schemes is realised from the economical viewpoint, heavy traffic will deteriorate social environment as well as the function of project<br>Step 2 : The scheme of AL-I is an unlikely practical solution. The land availability is quite limited<br>Step 3 : The scheme of AL-IIb has some possibility to be examined at the further stage. In case that the design speed of 80km/h is too high to avoid physical constraints, the design speed of 60km/h will be adoptable (i.e. Rmin = 230m can be reduced to 125m)<br>Step 4 : Thus, it is concluded that the scheme of AL-IIb is selected in this segment | | | |

Table 3.8 : Comparison and Evaluation of Alternatives in Kampung-Kuchai Area (Segment C-D)

| Item / Alternative | AL-I (Riverside Scheme) | AL-II (Hillside Scheme) |
|---|---|---|
| Background | Original Route : Running along the riverside of Sungai Klang and Sungai Kuyuh | New Idea : Running along between the existing developed area and undeveloped rolling hills to mitigate possible disturbance of the existing developed area |
| Road Length (m) — Throughway | 7550 | 8100 |
| Road Length (m) — Frontage Road | 0 | 0 |
| Road Length (m) — Interchange Ramp | 2520 | 3020 |
| Proposed Right-of-Way | 40m (38%) : 60m (50%) : 80m (12%) | 40m (22%) : 60m (63%) : 80m (15%) |
| 1. Land availability | Route corridor within committed housing development areas has been reserved. It is necessary to overpass existing small scale factories and settlements along Jalan Puchong by elevated road or viaduct to avoid barrier affect of access-controlled road. Nevertheless, the area is not heavily built-up<br>Fair | A large part of the route passes through estate land which can be acquired. Only a few estate houses lie within the route corridor<br>Fair |
| 2. Impact on Social Environment | A viaduct design could have adverse aesthetic view. Passing in between Taman Kinrara and Sungai Klang, impact due to noise and air pollution is anticipated to be minimum<br>Fair | The occurrence of complaints due to noise and air pollution, etc and of being a public nuisance during construction is deemed to be minimum<br>Good |
| 3. Future Traffic Demand | Direct access to the planned Petaling Jaya-Puchong road allows an effective road network to be developed. Good access to Petaling Jaya and Puchong will be provided<br>Good | The interchange with Jalan Puchong is located too near to the planned Puchong-Sungei Besi road for an effective road network to be developed. Access to Petaling Jaya is not good<br>Poor |
| 4. Construction Economy | Possibility of poor subsurface soil and hydrological condition could affect construction cost. The route is to pass by the north of Bukit Tandang to avoid excessive earth work<br>Cost Index = 1.00 Fair | Slope stabilisation will be necessary along a longer portion of the route. This would affect construction cost<br>Cost Index = 1.03 Fair |
| 5. Road User Benefit | The interchange to Petaling-Puchong road is conveniently located for the predominant traffic direction to Petaling Jaya<br>Good | The predominant traffic direction at the interchange to Jalan Puchong is towards Petaling Jaya. However the interchange's location causes some road users to pay a higher transport cost<br>Bad |
| 6. Development Impact | Very little undeveloped land is left along the route so that impact of construction on new development will be limited<br>Fair | Impact of construction on new development in the hilly area is expected to be limited due to lack of development pressure<br>Fair |
| Evaluation | Step 1 : The scheme of AL-I and AL-II has almost the same level in the aspects of land availability, construction economy and development impact<br>Step 2 : In general, the scheme of AL-II seems to be slightly superior in the aspect of social environment<br>Step 3 : As for future traffic demand and road user's benefit, the scheme of AL-I is significantly superior to that of AL-II because of direct connection to Petaling Jaya-Puchong new road and its effective distan to Puchong-Sungei Besi road, which is designated as its parallel feeder system<br>Step 4 : Thus, it is recommended that AL-I be selected in this segment | |

Table 3.9: Comparison and Evaluation of Alternatives in Kampung Teluk Gong Besar Area (Segment F-G)

| Item \ Alternative | | AL-I (Sri Andalas Route) | AL-II (Klang Jaya Route) |
|---|---|---|---|
| Background | | Original Route : Running on the boundary road of Jalan 1 Kaw 3 between Taman Sri Andalas and Taman Klang Jaya | New Idea : Running in between existing residential area and agricultural area to mitigate possible disturbance of existing developed area |
| Road Length (m) | Throughway | 8050 | 9300 |
| | Frontage Road | 3000 | 700 |
| | Interchange Ramp | 3780 | 3220 |
| Proposed Right-of-Way | | 40m (33%) : 60m (19%) : 80m (48%) | 60m (94%) : 80m (6%) |
| 1. Land availability | | Acquisition of land and properties along Jalan Kim Chuan is necessary. Although Jalan 1 Kaw 3 has a road of 40m, the construction of an elevated road on viaduct may encounter protests from residents<br>Poor | Acquisition of land belonging to a palm oil estate is necessary for a larger portion of the route<br>Fair |
| 2. Impact on Social Environment | | Countermeasures to mitigate adverse affects such as public nuisance during construction, adverse aesthetic view of viaduct, noise and air pollution, etc. are necessary in the existing residential area<br>Poor | The route bypasses the south of Taman Klang Jaya in order to achieve an acceptable social environment<br>Good |
| 3. Future Traffic Demand | | Ease in transfer from highway to collector roads such as Jalan Langat, Jalan Kim Chuan and Jalan 1 Kaw 3. This scheme has an advantage to be nearer to Klang town centre which is the major attractor in this area<br>Good | Although the functional road network is enhanced, it has a lesser degree of combination with existing collector roads<br>Fair |
| 4. Construction Economy | | A high cost is anticipated for the construction of 1.3km long viaduct. Construction and maintenance cost is also inflated by the necessity to introduce countermeasures for pollution<br>Cost Index = 2.30 Poor | This route is 1.25km longer than AL-I but its overall cost will still be lower than that of AL-I because of level road design<br>Cost Index = 1.00 Fair |
| 5. Road User Benefit | | An interchange located at the existing intersection of Jalan Langat with Jalan Kim Chuan provides a shorter route for the predominant traffic flow direction towards Klang town centre<br>Fair | An interchange to Jalan Langat is 2km away from the existing intersection of Jalan Langat with Jalan Kim Chuan Therefore the predominant traffic flow from AL-II towards Klang town centre has to travel a longer distance compared to that of AL-I, thereby incurring a higher transport cost<br>Poor |
| 6. Development Impact | | Possible development impact is limited because a larger portion of its corridor is already or being developed<br>Poor | The development of surrounding estate land into housing area could be accelerated by the construction of this road which forms part of a ring road for the Klang Municipality Area<br>Good |
| Evaluation | | Step 1 : The scheme of AL-I is slightly superior to that of AL-II in the aspects of future traffic demand and road user's benefit<br>On the other hand the scheme of AL-II is significantly superior to that of AL-I in the aspects of social environment and development impact<br>Step 2 : The suitable countermeasures taken in the scheme of AL-I to mitigate adverse effects (i.e. public nuisance during construction, adverse aesthetic view of viaduct, noise and air pollution, etc) raise construction and maintenance costs considerably<br>Step 3 : In spite of a 1.25km longer stretch in AL-II, the construction cost of AL-I is estimated to be more expensive due to the construction of 1.3km long viaduct on the boundary road of existing housing area<br>Step 4 : Thus, it is reasonable that the scheme of AL-II is proposed | |

Table 3.10: Comparison and Evaluation of Alternatives in Subang Area (Segment J-K)

| Item / Alternative | | AL-I (Batu Tiga Route) | AL-II (Subang Route) |
|---|---|---|---|
| Background | | New Idea : Running on the new Jalan TUDM-Shah Alam | Original Route : Running along the western end of Subang Jaya and Seafield Development |
| Road Length (m) | Throughway | 6850 | 6500 |
| | Frontage Road | 3200 | 0 |
| | Interchange Ramp | 9800 | 9800 |
| Proposed Right-of-Way | | 60m (56%) : 80m (44%) | 60m (100%) |
| 1. Land availability | | The utilization of existing R.O.W. of the new Jalan TUDM-Shah Alam will minimise land acquisition area<br>Fair | The reserved corridor is presently planted with palm oil trees and the landuse in the area is designated as buffer zone<br>Fair |
| 2. Impact on Social Environment | | It is possible to design the road to minimise possible adverse effects of pollution in a localised built-up area. Therefore the proposed scheme can be acceptable to the public<br>Fair | No significant adverse effect is anticipated in a buffer zone<br>Fair |
| 3. Future Traffic Demand | | The functional road network is enhanced without reducing the function of Jalan TUDM-Shah Alam. At the same time the construction of one interchange fewer on Federal Route 2 within a 6km stretch can avert decrease in mobility on the existing highway<br>Fair | Enhancement to the functional road network is anticipated. However this route results in having five interchanges on Federal Route 2 within a 6km stretch<br>Fair |
| 4. Construction Economy | | This scheme enables the use of same interchange and a common route for Jalan TUDM-Shah Alam and a major portion of N-S Link, thus savings in construction cost is anticipated<br>Cost Index = 1.00 Good | Cost for the construction of own interchange is a due investment warranted by the forecasted heavy traffic volume<br>Cost Index = 1.45 Fair |
| 5. Road User Benefit | | Although a mixture of road users is anticipated, this scheme has sufficient capacity to keep desirable mobility level for each type of users<br>Fair | Users are expected to benefit more due to higher degree of mobility made possible by own alignment<br>Good |
| 6. Development Impact | | Development of the Batu Tiga area along Jalan TUDM-Shah Alam can be anticipated<br>Fair | The area is designated as buffer zone<br>N/A |
| Evaluation | | Step 1 : The scheme of both AL-I and AL-II has almost the same level on land availability and social environment<br>Step 2 : Access and egress traffic to Federal Route 2 from both N-S Link and JKR's new road are modest so it will be able to adopt a practical type of interchange<br>Step 3 : If the scheme of AL-II is adopted, five interchanges will be located on Federal Route 2 within a 6km stretch. Complicated traffic movements will decrease the mobility on Federal Route 2<br>Step 4 : The scheme of AL-I is superior to that of AL-II on construction economy, while AL-II has an advantage on road user's benefit<br>Step 5 : Thus, it is recommended that AL-I be selected in this segment | |

Table 3.11: Comparison and Evaluation of Alternatives in Kampung Bahru Puchong Area (Segment L-M)

| Item / Alternative | | AL-I (Northern Route) | AL-II (Southern Route) |
|---|---|---|---|
| Background | | Original Route : Running in the boundary between urbanised and agricultural area | New Idea : Bypassing wide ex-mining field in the south |
| Road Length (m) | Throughway | 11570 | 12720 |
| | Frontage Road | 0 | 0 |
| | Interchange Ramp | 1000 | 2750 |
| Proposed Right-of-Way | | 60m (100%) | 60m (100%) |
| 1. Land availability | | A larger portion of the route lies on ex-mining land which still belongs to the State Government<br>Good | A larger portion of the route lies on estate land which has to be acquired<br>Fair |
| 2. Impact on Social Environment | | Most of the surrounding area which comprises ex-mining land and agricultural landuse is not in a development pressure area. Thus impact on social environment is immaterial<br>N/A | The surrounding area under agricultural landuse is not in a development pressure area. Thus impact on social environment is immaterial<br>N/A |
| 3. Future Traffic Demand | | From the road network standpoint, the predominant traffic flow at the junction of N-S Link with the future South Klang Valley Expressway is in the direction towards the latter. However, the location of the junction in this scheme is unfavourable to the predominant traffic flow<br>Poor | This is a preferable route focussing on the linkage between Kuala Lumpur-Seremban Expressway and South Klang Valley Expressway. This desire line is expected to have a heavier traffic flow in the area<br>Good |
| 4. Construction Economy | | The necessity for backfilling former mining ponds and countermeasures for adverse subsurface soil condition tends to increase construction cost<br>Cost Index = 1.09 Poor | Favourable subsurface soil condition is anticipated for this route so there is no need for countermeasures to be taken<br>Cost Index = 1.00 Fair |
| 5. Road User Benefit | | The unfavourable location of its junction with the the future South Klang Valley Expressway causes road users going in the predominant traffic flow direction to pay a higher transport cost<br>Poor | This scheme enables the construction of a junction with the future South Klang Valley Expressway at a suitable location for the predominant traffic flow direction, thereby reducing these road users' transport cost<br>Good |
| 6. Development Impact | | The surrounding area is not considered as a development pressure area<br>N/A | The surrounding area is not considered as a development pressure area<br>N/A |
| Evaluation | | Step 1 : The traffic demand forecast reveals that the traffic between Kuala Lumpur-Seremban Expressway and South Klang Valley Expressway is predominant in this area. Thus, the scheme of AL-II is superior to that of AL-I in the aspects of future traffic demand and road user's benefit<br>Step 2 : On land availability, AL-I is slightly superior to AL-II<br>Step 3 : As for construction economy, AL-II is slightly superior to AL-I. Although soil investigation is not carried out yet at the ex-mining field, adverse subsurface soil conditions are generally reported<br>Step 4 : It is recommended that the scheme of AL-II be selected in this segment | |

Table 3.12: Comparison and Evaluation of Alternatives in Kampung Abu Bakar Area (Segment N-O)

| Item / Alternative | AL-I (Combination of Junction and Interchange Scheme - Kajang Route) | AL-II (Separation of Junction and Interchange Scheme - Bangi Newtown Route) |
|---|---|---|
| Background | New Idea : Connecting with Kuala Lumpur-Seremban Expressway at an existing interchange so that all traffic will be distributed at a single place | Original Idea : Connecting with Kuala Lumpur-Seremban Expressway in between Kajang and Bangi Interchanges in order to distribute traffic to Bangi Newtown at 2 places |
| Road Length (m) Throughway | 6220 | 5500 |
| Road Length (m) Frontage Road | 2000 | 0 |
| Road Length (m) Interchange Ramp | 5900 | 4900 |
| Proposed Right-of-Way | 60m (68%) : 80m (32%) | 60m (100%) |
| 1. Land availability | The combined structure requires less land acquisition compared to separate entities, but acquisition of additional land around existing interchange is not always readily available due to committed plans<br>Fair | A larger land area is required for separate junction and interchange structures but the location of the new junction has been identified in the Bangi Structure Plan<br>Fair |
| 2. Impact on Social Environment | Adverse effect such as noise and air pollution due to congestion at the interchange is anticipated<br>Poor | Effect of noise and air pollution from traffic demand is dispersed by three locations<br>Fair |
| 3. Future Traffic Demand | The concentration of long trip and local traffic at a single point causes a reduction on the capacity of both junction and interchange<br>Bad | The division of roads by their function is clearer in this scheme. There is no need for the expressway which provides a higher degree of mobility to mix with the arterial roads. Congestion at the interchange is averted by distributing the demand to Bangi Newtown at two separate locations<br>Good |
| 4. Construction Economy | The combined structure is required to service 6 legs. Thus a structure with more than three levels is necessary and a gigantic cost is anticipated<br>Cost Index = 1.31 Bad | A 2-level practical type junction construction is possible. There is no need to improve existing interchange design<br>Cost Index = 1.00 Fair |
| 5. Road User Benefit | Complicated direction turnings are anticipated at the combined structure. Weaving traffic aggravates road safety. In the case of accident at the interchange, it becomes easily congested because of the concentration of traffic at one point<br>Bad | Traffic flow turnings at proposed junction and existing interchange are simple and well directed. A lower transport cost and higher road safety for users are anticipated<br>Good |
| 6. Development Impact | Effect of agglomeration of activities location around the interchange can be anticipated<br>Fair | Although location of activities around the junction is not enhanced in any way, some affect on the development around the two existing interchanges can be anticipated<br>Poor |
| Evaluation | Step 1 : If the scheme of AL-I is adopted, four links of Kuala Lumpur-Seremban Expressway, Kajang-Puchong road, planned direct access to the Newtown centre and North-South Link will be connected to each other at one location. A too complicated linkage and too concentrated traffic cannot bear any significant benefit<br>Step 2 : The scheme of AL-II is overwhelmingly superior to that of AL-I in almost every aspect<br>Step 3 : Thus, it is concluded that AL-II is selected in this segment | |

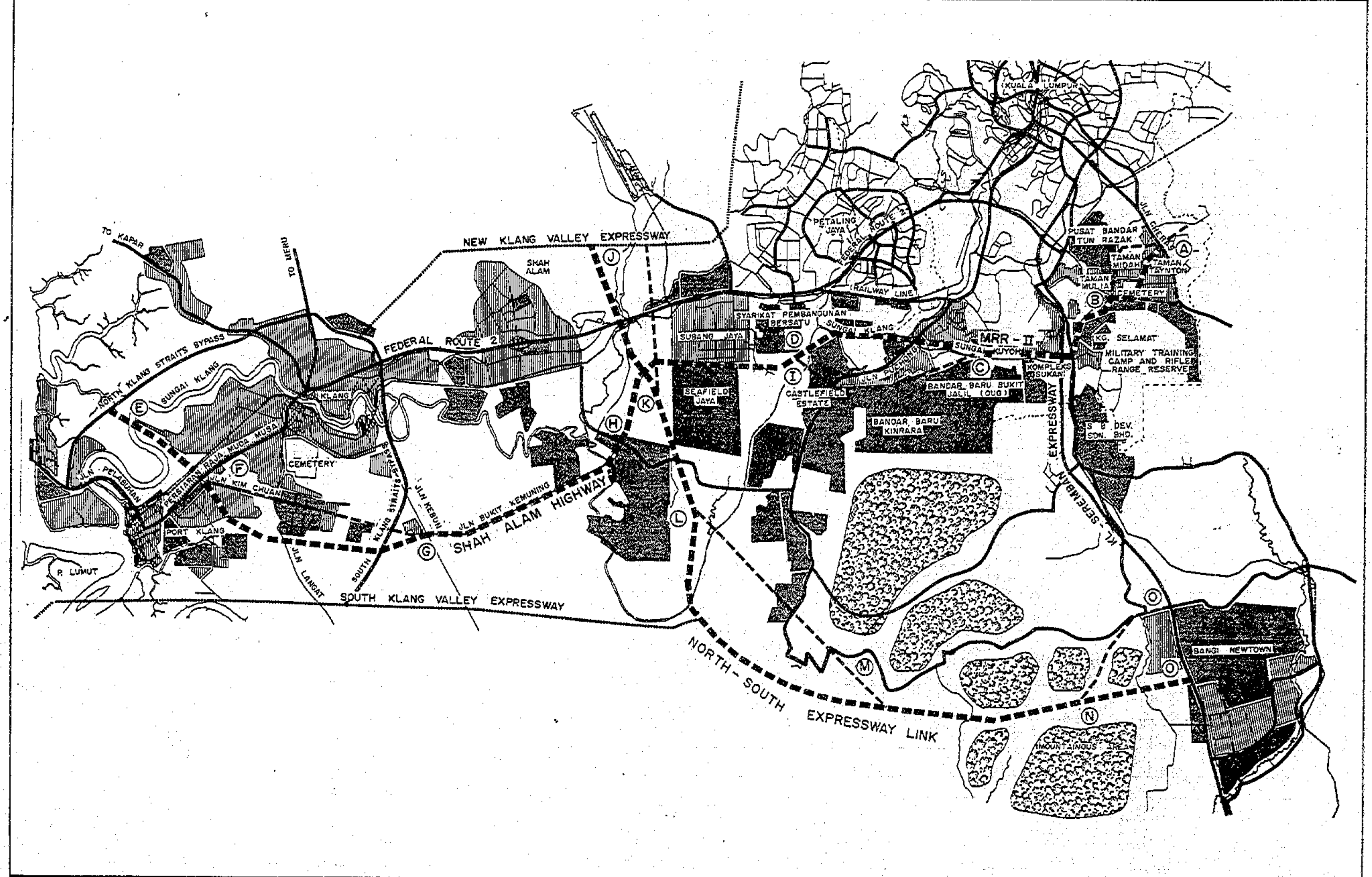


FIG. 3.6 : PROPOSED ROUTE AND ALTERNATIVES

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LEGEND:
- PROPOSED ROUTE
- ALTERNATIVE ROUTE
- PLANNED ROAD
- EXISTING ROAD

SCALE: 0 1 2 4km

N

## 3.3 Further Study on Alternative Route in Port Klang Area

### 3.3.1 Alternative Route

In the stretch between Klang West IC and Kim chuan IC, an alternative route is set in the protuberant swampy land encompassed by the meandering Sungai Klang as shown in Figure 3.3.1. This route aims to:-

(i) utilize a planned road network of PKNS Port Klang Area Development Project;
(ii) avoid the violation of Teluk Pulai Malay Reservation; and
(iii) select a better alignment.

### 3.3.2 Outline of PKNS Port Klang Area Development Project

The project comprising 2932 acre (1187 ha) of industrial development is located to the south east of the existing North Port in Port Klang. The layout plan for the southern part of the project area has been approved and the construction of infrastructure is nearly completed. However, the layout plan for the eastern part is still conceptual. Both North Klang Straits Bypass (NKSB) and Jalan Pelabuhan presently form a backbone of road network in the project area. Most of the large-scale industrial development are planned to be in the land west of NKSB while the residential/commercial/ institutional area are in the east.

Table 3.3.1 shows the allocation of area by each landuse.

Table 3.3.1: Allocation of Area by Landuse

| Landuse | Area | | Percentage |
|---|---|---|---|
| 1. Industrial | 1400 acre | ( 567ha) | 47.8% |
| 2. Residential | 443 | ( 179 ) | 15.1 |
| 3. Commercial | 93 | ( 38 ) | 3.2 |
| 4. Town Centre | 50 | ( 20 ) | 1.8 |
| 5. Public Utilities | 51 | ( 21 ) | 1.7 |
| 6. Recreation | 230 | ( 93 ) | 7.8 |
| 7. Green Area | 201 | ( 82 ) | 6.9 |
| 8. School | 50 | ( 20 ) | 1.7 |
| 9. Flood Retention Pond | 44 | ( 18 ) | 1.5 |
| 10. Oxidation Pond/Drain | 40 | ( 16 ) | 1.4 |
| 11. Electric Transmission Line | 35 | ( 14 ) | 1.2 |
| 12. Road | 295 | ( 119 ) | 10.0 |
| | 2932 acre | (1187ha) | 100.0 |

### 3.3.3 Comparison and Evaluation of Alternative Route

The original route is planned to run along the lee side of the existing dike of Sungai Klang because this route can pass on rather preferable soil condition and enable to minimize such adverse effects as a community disruption and deterioration of environment brought about by a high standard access controlled road.

On the contrary, the alternative route is considered to run on the other side of Sungai Klang where such landuse as residential/town centre/schools are allocated in the conceptual layout plan of PKNS Port Klang Area Development.

Therefore, the design standard of the alternative route should decrease from U5 to U4 or less due to the landuse along the route. Even if the design standard of U4 is adopted, a special environmental measure such as a frontage road with environmental buffer, pedestrian bridges and so forth are required to cope with the number of anticipated heavy vehicles going to or coming from the large-scale industrial development area.

The local traffic circulation will be affected considerably unless a frontage road is installed on both sides of the new highway.

The salient features of the alternative route is summarized in Table 3.3.2 as compared with the original route.

The evaluation of alternative route is:-

(i) Shah Alam Highway terminates at Kim Chuan IC and the alternative route is regarded as an extension of Shah Alam Highway of which the design standard is lower. Accordingly, the functional road network in Klang district is deformed and devaluated;

(ii) Since PKNS Port Klang Area Development project is a predominant industrial development, both high rate and volume of heavy vehicles are anticipated. These heavy vehicles will run on the alternative route, notwithstanding its design standard and adjacent landuse whereby, they will spoil environment envisaged in the conceptual layout of the town centre and its surrounding residential and institution areas;

(iii) Due to an expected poor sub-surface soil condition on the entire stretch, special treatment to roadbed soil and subgrade will be necessary and this treatment will increase the construction cost;

(iv) The alternative route will cause disruption in the community even if some pedestrian bridges are installed;

(v) On the contrary, the original route has the advantage of possible extension to a planned road network in the industrial area;

(vi) It is concluded that the original route (AL-I) is superior to the alternative route (AL-II) from the engineering viewpoint.

It is recommended to shift the original route away from the small holders and Teluk Pulai Malay Reservation by running on the dike of Sungai Klang if certain difficulty should occur during land acquisition. This countermeasure is however subject to DID's consent.

Table 3.3.2 Alternative Routes

| ALTERNATIVE | | AL-I (NORTHERN ROUTE) | AL-II (SOUTHERN ROUTE) |
|---|---|---|---|
| Background | | Original Route: Runs along the northern dike of Sungai Klang | New Idea: Runs on a planned road in residential area |
| Terrain | | Flat | Flat/Swampy |
| Road Length | Throughway (m) | 3,500 | 3,500 |
| | Frontage Road | 0 | 2,200 |
| | Interchange Ramp | 1,500 | 0 |
| Physical Constraint/Landuse/ Environment/Road Network/ Traffic Demand, etc. | | - to run along the lee side of the existing dike of Sungai Klang<br>- to lie on rather preferable sub-surface soil section<br>- to avoid the disturbance of local traffic in residential area<br>- to form a trumpet-type interchange at the inter-section with NKSB<br>- to enable an extension toward the north-west industrial area<br>- to form a ring road joining NKSB with South Klang Straits Bypass | - to run on a planned local road in residential area<br>- to avoid the violation of Teluk Pulai Malay Reservation<br>- to abandon an access-controllled highway to avoid community disruption<br>- to provide with an access to residential area and then form at-grade intersection with NKSB<br>- to require a special soft soil treatment due to poor sub-surface soil condition<br>- to select better horizontal alignment<br>- to require a special environ-mental measure to prevent the deterioration of residential environment |

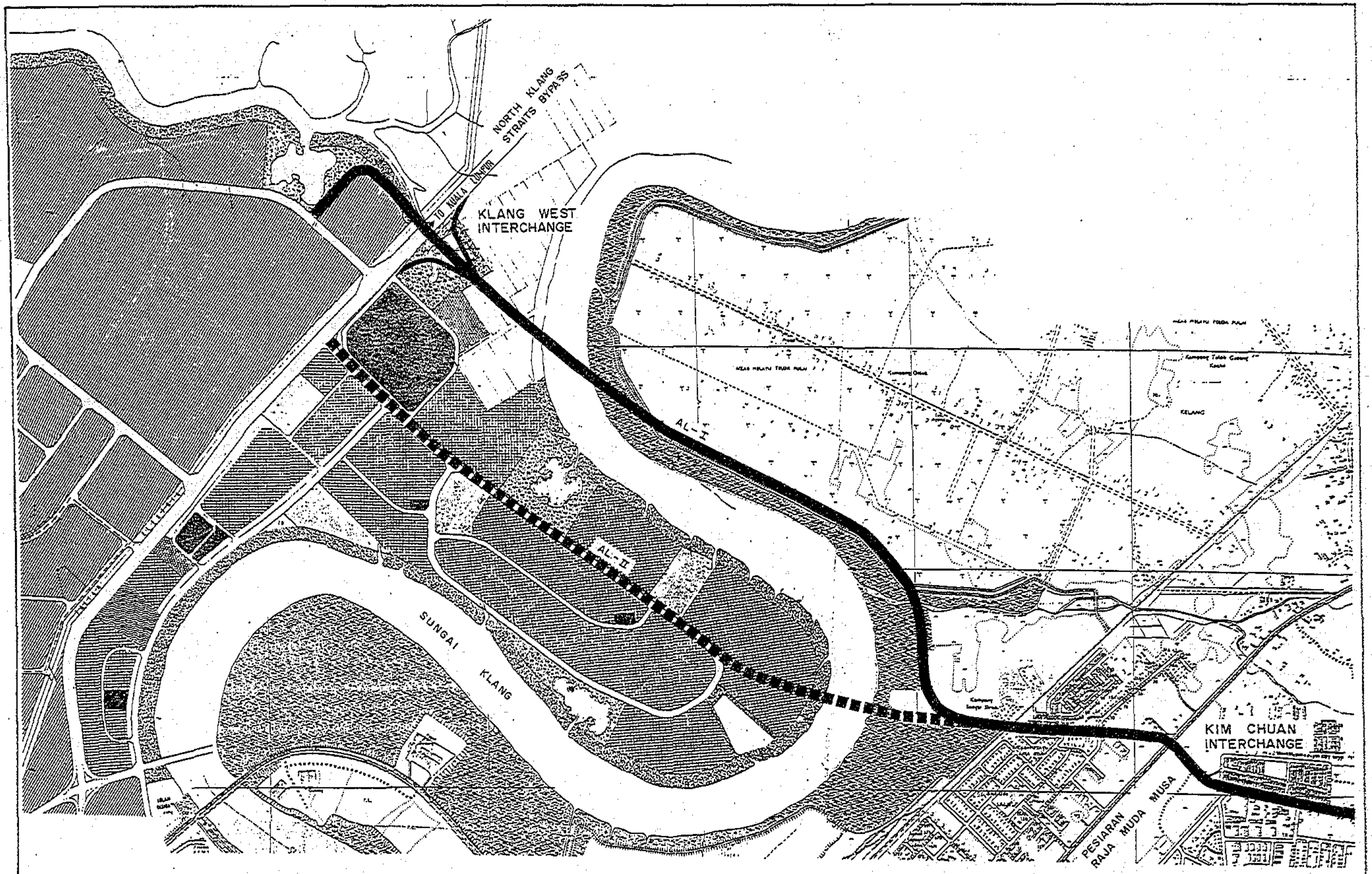



FIG. 3.3.1: ROUTE LOCATION IN PKNS PORT KLANG AREA DEVELOPMENT

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

# APPENDIX TO CHAPTER 5

## Preliminary Engineering Study

## 5.1 Right-of-Way-Situation

### 5.1.1 Constraints due to approved development plans.

(a) RUMAH TULIN Area

The R.O.W of MRR-II in Rumah Tulin area is strictly constrained by the registered layout plan of the industrial development with the Planning and Building Control Department of DBKL.

The area comprises eight (8) separate titled lots of various sizes. The proposed route of MRR-II is selected to pass through the controls with minimum violation of these lots as shown in Figure 5.1.1. Only 9.7% of the land belonging to RUMAH TULIN will be affected by the proposed route and most of this area is zoned as local road and LLN reserved land so that the building layout plan is not affected by MRR-II's R.O.W.

| AREA OF RUMAH TULIN | ACRES | ROAD RESERVE (MRR-II) (acres) | |
|---|---|---|---|
| No.1 | 26.8 | 2.19 | ( 8.2%) |
| No.2 | 9.85 | 1.40 | (14.2%) |
| No.3 | 5.7 | 0 | |
| No.4 | 0.345 | 0 | |
| No.5 | 2.9 | 1.30 | (44.8%) |
| No.6 | 0.976 | 0 | |
| No.7 | 2.9 | 0 | |
| No.8 | 2.6 | 0.14 | ( 5.4%) |
| TOTAL: | 52.071 | 5.03 | ( 9.7%) |

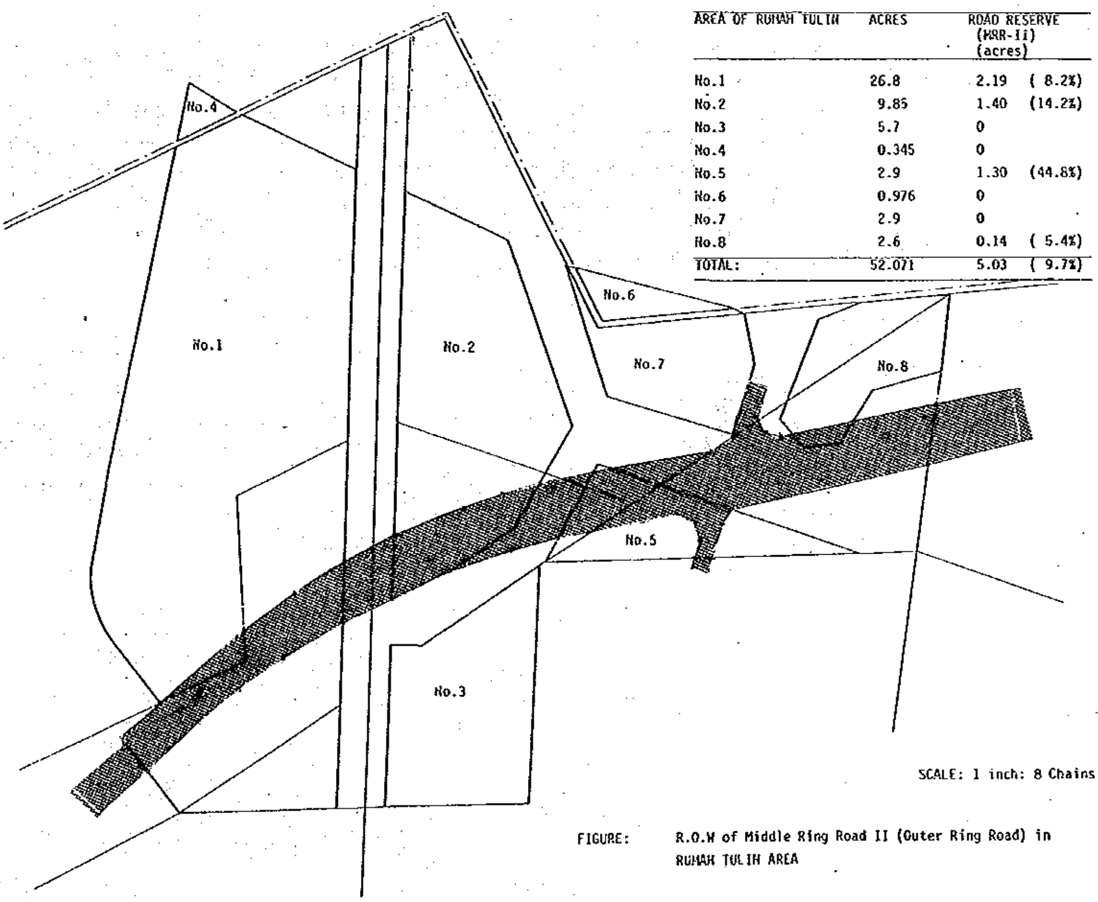



FIGURE: R.O.W of Middle Ring Road II (Outer Ring Road) in RUMAH TULIN AREA

Figure 5.1.1: R.O.W of Middle Ring Road II in RUMAH TULIN AREA

(b) KIM CHUAN Area

Originally JKR HQ has prepared a road improvement plan at the intersection of Pesiaran Raja Muda Musa with Jalan Kim Chuan-Jalan Petola. Land requirement for the construction of a diamond type interchange has been indicated by JKR's plan.

In the route selection study, the Study Team identified this intersection as the location of a service type interchange (Kim Chuan IC) on Shah Alam Highwy. In view of the land constraints indicated in Figure 5.1.2 and the estimated high traffic volume to be managed at this interchange, the minimum R.O.W sufficient for a 3-level diamond interchanged should be reserved for Kim Chuan IC.

(c) LIPAT GANDA Sdn Bhd/TILLER INDUSTRY Sdn Bhd Area

The selected route of Shah Alam Highway in the Kampong Teluk Gadong Besar Area (Segment F-G, AL-II) has to aviod the LIPAT GANDA Sdn Bhd/TILLER INDUSTRY Sdn Bhd development area as shown in the layout plan approved by the Town and Country Planning Department of Selangor State by taking on the horizontal alignment depicted in Figure 5.1.3.

5.1.2 R.O.W Requirement Area

Landuse in the R.O.W is categorised into seven(7) types for purpose of estimating land acquisition cost. Table 5.1.1 summarises the area of R.O.W by road section and landuse type.

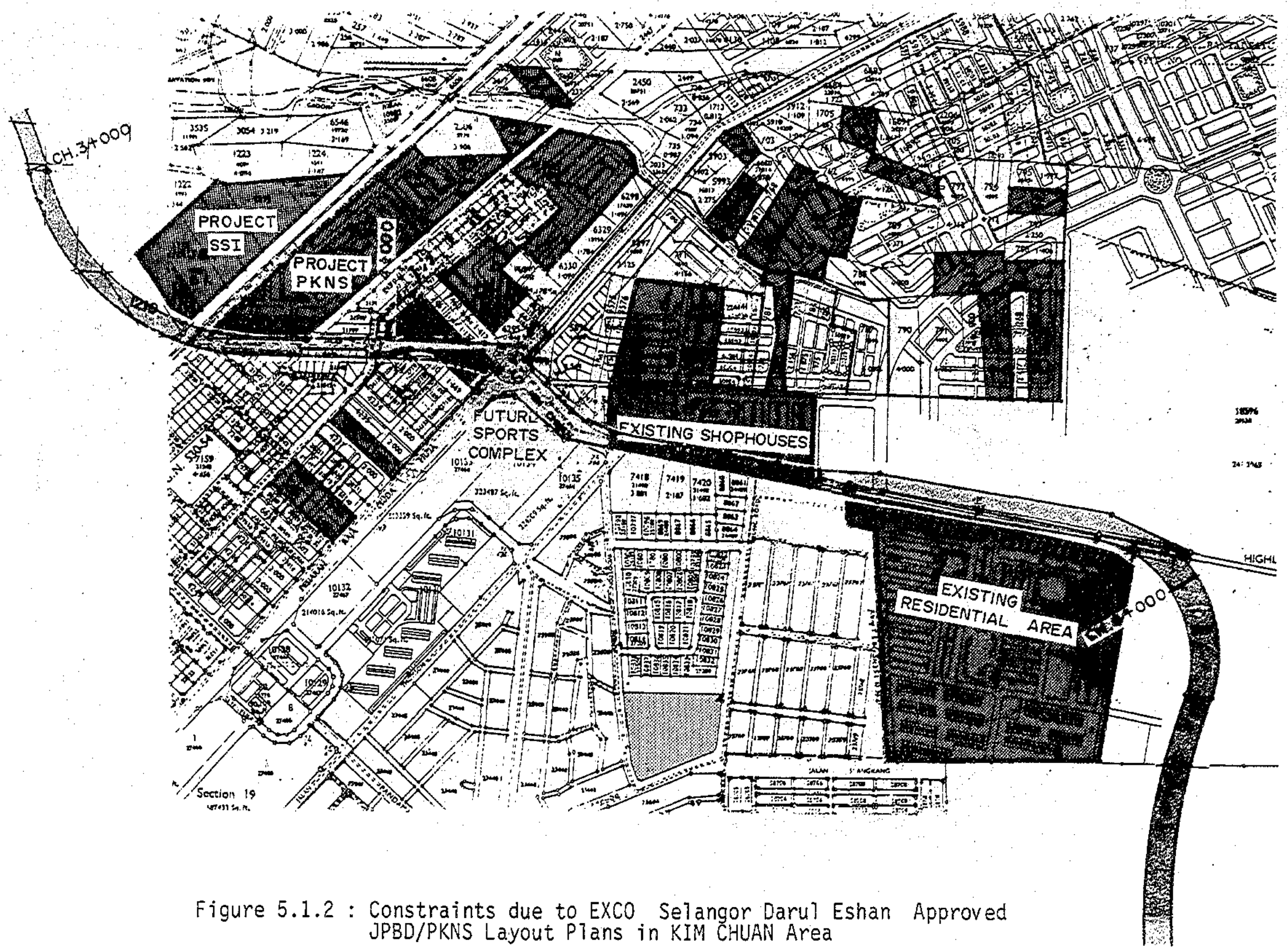



Figure 5.1.2 : Constraints due to EXCO Selangor Darul Eshan Approved JPBD/PKNS Layout Plans in KIM CHUAN Area

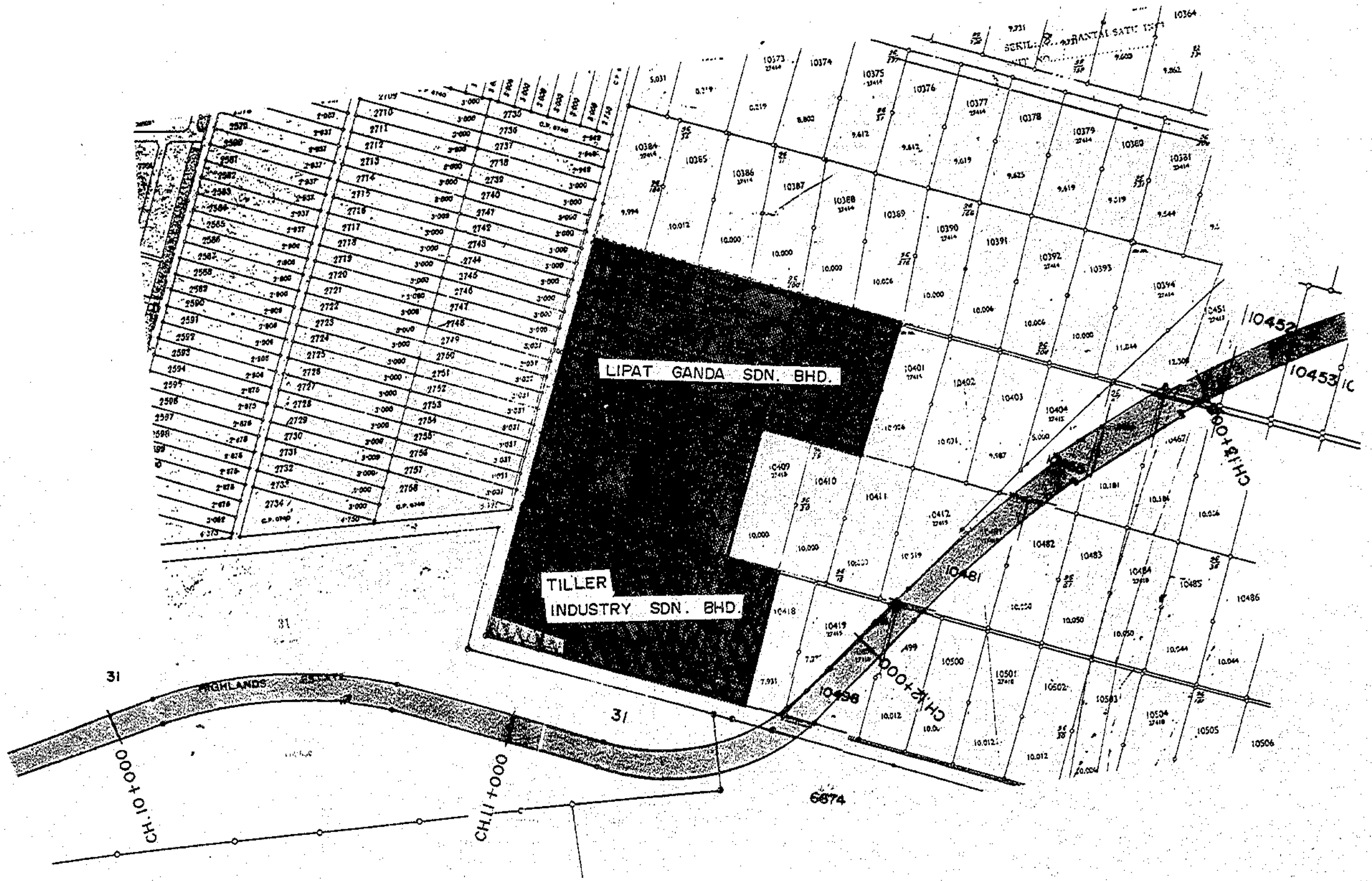



Figure 5.1.3 : Constraints due to EXCO Selangor Darul Ehsan Approved Layout Plans for LIPAT GANDA Sdn Bhd and TILLER INDUSTRY Sdn Bhd.

## Table 5.1.1 : Area of R.O.W by Road Section and Landuse Type

LANDUSE TYPE:
1. Agriculture
2. Industrial/Commercial
3. Residential
4. Malay Reservation
5. Road Reserve
6. Forest Reserve
7. Existing Road, River, Rail Reserve

LANDUSE TYPE: (AREA IN'000 M2)

| SHAH ALAM HIGHWAY/MRR-II | TYPE 1 | TYPE 2 | TYPE 3 | TYPE 4 | TYPE 5 | TYPE 6 | TYPE 7 | TOTAL |
|---|---|---|---|---|---|---|---|---|
| Section I | | | | | | | | |
| 1. Throughway | 233.2 | 36.8 | | 62.1 | | | 80.7 | 412.8 |
| 2. Klang West IC | | | | | | 45.1 | 13.7 | 58.8 |
| 3. KimChuan IC | | 11.2 | | | | | 26.6 | 37.8 |
| 4. Langat IC | 5.2 | | | | | | | 5.2 |
| Sub-total | 238.4 | 48 | 0 | 62.1 | 0 | 45.1 | 121 | 514.6 |
| Section II | | | | | | | | |
| 1. Throughway | 440.8 | 190.7 | | | | | 185.6 | 817.1 |
| 2. Klang East IC | 123.8 | | | | | | 8.9 | 132.7 |
| 3. Shah Alam West IC | | 4.6 | | | | | 13.1 | 17.7 |
| 4. Shah Alam South IC | | | 106.1 | | | | 15.1 | 121.2 |
| 5. Shah Alam East IC | 3.1 | | | | | | 3.1 | 6.2 |
| Sub-total | 567.7 | 195.3 | 106.1 | 0 | 0 | 0 | 225.8 | 1094.9 |
| Section III | | | | | | | | |
| 1. Throughway | 878 | 187.3 | 210.1 | | | | 59.5 | 1334.9 |
| 2. Subang South IC | 18.2 | | | | | | | 18.2 |
| 3. Sunway IC | 60.2 | | | | | | | 60.2 |
| 4. Kinrara IC | 18.1 | | | | | | | 18.1 |
| 5. Awan Besar IC | | | 38.3 | | | | | 38.3 |
| 6. Sri Petaling West IC | | | 11.1 | | | | | 11.1 |
| 7. Sri Petaling East IC | | | 9.3 | | | | 131.1 | 140.4 |
| Sub-total | 974.5 | 187.3 | 268.8 | 0 | 0 | 0 | 190.6 | 1621.2 |
| Section IV | | | | | | | | |
| 1. Throughway | 213.9 | | | | | | | 213.9 |
| Sub-total | 213.9 | 0 | 0. | 0 | 0 | 0 | 0 | 213.9 |
| TOTAL FOR SHAH ALAM HIGHWAY/MRR-II | 1994.5 | 430.6 | 374.9 | 62.1 | 0 | 45.1 | | 2907.2 |
| NORTH-SOUTH EXPRESSWAY LINK | | | | | | | | |
| Section I | | | | | | | | |
| 1. Throughway | 182.7 | | | | 146.3 | | 51.8 | 380.8 |
| 2. New Klang Valley IC | 123.8 | | | | | | 95.4 | 219.2 |
| 3. Batu Tiga IC | 41.9 | | | | | | 34.1 | 76 |
| 4. Subang West IC | 223.2 | | | | | | | 223.2 |
| Sub-total | 571.6 | 0 | 0 | 0 | 146.3 | 0 | 181.3 | 899.2 |
| Section II | | | | | | | | |
| 1. Throughway | 1441.1 | | | 262.5 | | | 43.5 | 1747.1 |
| 2. HICOM East IC | 117.4 | | | | | | | 117.4 |
| 3. South Klang Valley IC | 95.1 | | | | | | | 95.1 |
| 4. Puchong South IC | 107.9 | | | | | | | 107.9 |
| 5. Bangi West IC | | | 112.1 | 17.1 | | | 33.8 | 163 |
| Sub-total | 1761.5 | 0 | 112.1 | 279.6 | 0 | 0 | 77.3 | 2230.5 |
| TOTAL FOR NORTH-SOUTH EXPRESSWAY LINK | 2333 | 0 | 112 | 280 | 146 | 0 | 259 | 3129.7 |

## 5.2 Geological Analysis and Soil Survey

### 5.2.1 Ground Conditions of Each Site

#### (1) Sri Petaling Interchange

##### (a) Topographic and Geological Outlines

The proposed interchange site is located at about 11km Kuala Lumpur-Seremban Expressway at the existing Sungei Besi Interchange. The ground elevation in the vicinity of the site varies from about RL +47.00m to about RL +36.00m. On both sides of the existing Kuala Lumpur-Seremban Expressway are diversion roads which are relatively about 5 to 6m higher. Many wooden houses are located in the vicinity of the site. The area is expected to be a cut and fill area. Elevation of borehole BH-1 and BH-2 are RL +39.33m and RL +41.57m respectively. The site is situated in an area underlain by Kenny Hill formation as shown in Figure 5.2.1.

##### (b) Ground Condition at Sri Petaling Interchange Site

A total of two exploratory boreholes were sunk to a depth of about 25m deep from the ground surface. The boreholes were located on both sides of the Kuala Lumpur-Seremban Expressway.

Based on the results of the exploratory boreholes a geological cross-section was prepared and shown in Figure 5.2.2. As can be seen in Figure 5.2.2. the subsurface ground at the site can be broadly classified into the following two layers:-

(i) Fill
(ii) Kenny Hill Formation

The engineering properties of each soil layer/stratum is presented in Table 5.2.1. The physical properties versus depth are presented in Figure 5.2.2.

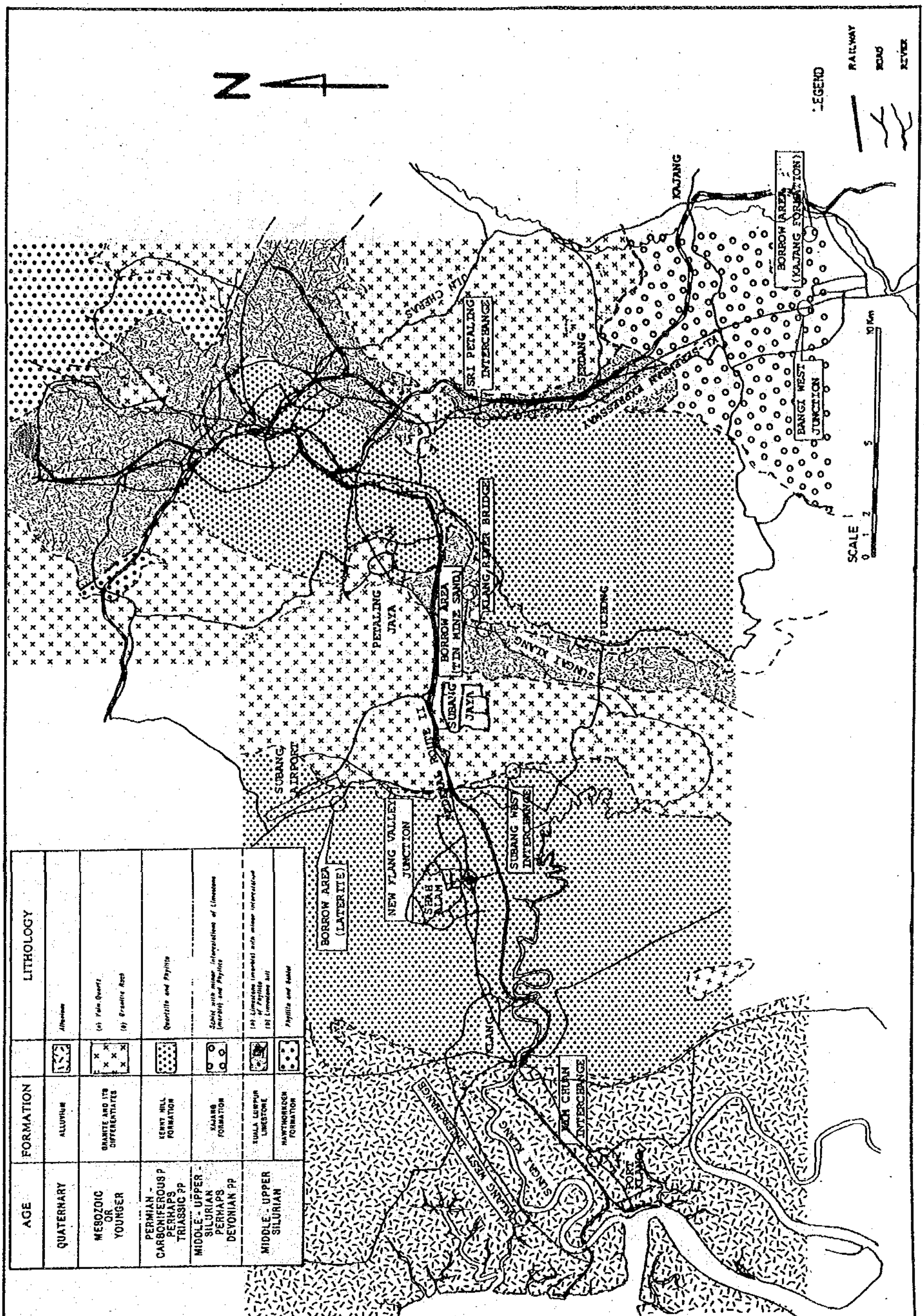



Figure 5.2.1Geological Map of the Sites and their Surrounding Area

Table 5.2.1 Summary of Engineering Properties of Soil Strata at Sri Petaling Interchange Site

| Formation | Strata | Thickness (m) | N-value | Grain Size Distribution (%) | | | | Water Content (%) | Specific Gravity | Wet Density (kN/m3) | Atterberg Limit (%) | | Cohesion (kN/m2) | Angle of Internal Friction | Preconsolidation Pressure (kN/m2) | Compression Index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Clay | Silt | Sand | Gravel | | | | Liquid Limit | Plastic Limit | | | | |
| Fill | | 1.50 ~ 4.0 | 2 ~ 9 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Kenny Hill Formation | * Medium to Stiff Sandy Silt | 3 | 6 ~ 30 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | * Medium to Dense Silty Sand | 3.50 | 16 ~ 19 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Medium to Stiff Silty Clay | 1.00 ~ 7.0 | 3 ~ 11 | 12 ~ 18 | 52 ~ 71 | 4 ~ 33 | 3 ~ 7 | 34 ~ 45 | 2.815 ~ 2.851 | - | - | - | - | - | - | - |
| | Very Stiff to Hard Silty Clay | 11.0 | 20 ~ 40 | 12 ~ 38 | 23 ~ 56 | 30 ~ 47 | 1 ~ 7 | 23 ~ 28 | 2.766 ~ 2.805 | - | ** 46 | ** 22 | - | - | - | - |
| | Hard Silty Clay | > 5 | > 50 | - | - | - | - | - | - | - | - | - | - | - | - | - |

* Encountered in 1 borehole only
** Tested one 1 sample only

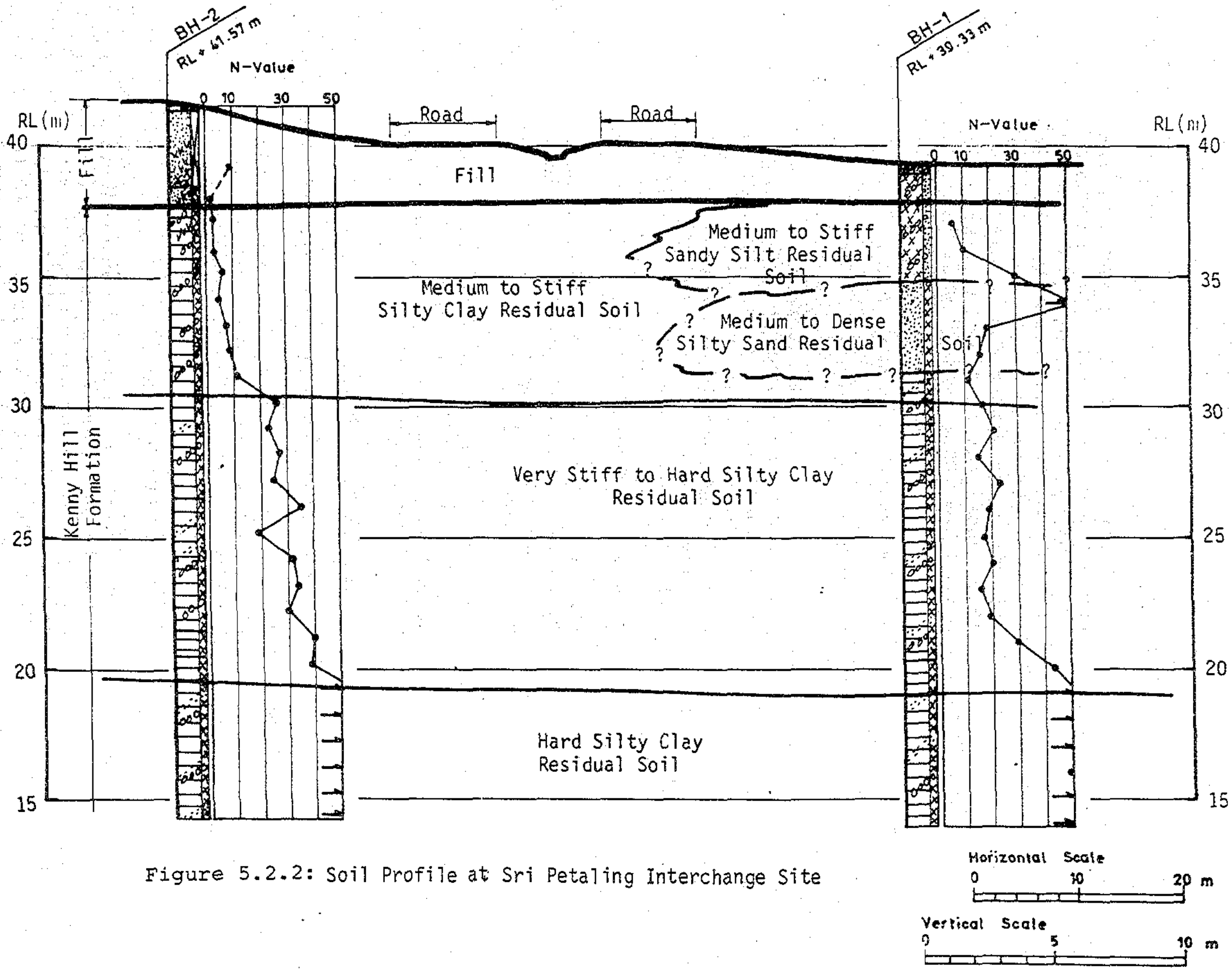



Figure 5.2.2: Soil Profile at Sri Petaling Interchange Site

(i) Fill

A layer of fill material was encountered in both the boreholes immediately below the existing ground surface. The confirmed thickness is about 1.50m to 4m. It consists of typically reddish brown to dark brown sand and sandy silt. The first two metres of this layer was manually excavated by auger to check for any underground facilities present. The N-value varies from 2 to 9.

(ii) Kenny Hill Formation

The Kenny Hill formation was encountered underlying the fill layer in the boreholes. It was encountered at elevation about RL +38.0m. The formation was completely weathered to residual soil especially the top portion in borehole BH-2. It consists of yellowish brown silty clay occassionally with gravel.

Laboratory soil test was only performed on the disturbed sample since no soft cohesive soil layer was encountered at the site.

This weathered Kenny Hill formation can be further divided into 5 strata depending on the N-values and the type of soil as follows:-

<u>Medium to Stiff Sandy Silt</u>

It was only found in borehole BH-1 underlying the fill layer. It is reddish to yellowish brown in colour with gravel. The N-value varies from 6 to 30. The thick-ness confirmed in BH-1 was 3m.

<u>Medium to Dense Silty Sand</u>

This stratum was also encountered in borehole BH-1 only below stratum (a). It is reddish brown in colour with gravel sized rock fragment. Typically the N-values are in the range of 16 to 19. The confirmed thickness observed in BH-1 was 3.50m.

Medium to Stiff Silty Clay

This stratum was encountered in both the boreholes. It is typically reddish to purplish brown clayey soil with sand and gravel sized rock fragment. The N-value gradually increases with depth as observed in borehole BH-1 from 3 to 11. The maximum thickness confirmed was about 7m. The water content in this layer is 34% to 45% and specific gravity of 2.816 to 2.851 as shown in Table 5.2.1 and Figure 5.2.2.

Very Still to Hard Silty Clay

The stratum was encountered in both the boreholes at almost the same elevation of about RL 30m. It consists of multiple colour soil of yellowish, reddish, purplish and creamy white clayey soil. Gravel sized rock fragment and weathered quartz veins are frequently observed. The N-values are quite consistent ranging typically from 20 to 40. The thickness in both the boreholes was almost the same, about 11.0m. The water content is about 23% to 28% and specific gravity of between 2.766 to 2.805.

Hard Silty Clay

The stratum was encountered in both boreholes at elevaiton between RL 19 to RL 20m. It also consists the same material as in the (d) stratum. The N-value was more than 50 and the confirmed thickness in this stratum was 5m.

(c) Pressuremeter Test

Pressuremeter tests were carried out in the fill and in the medium to still sandy silt and medium to stiff silty clay strata of the Kenny Hill formation. Result of the tests are summarized in the table below.

Table 5.2.2 : Summary of Pressuremeter Test Result at Sri Petaling Interchange

| Formation | Strata | Depth (m) (BH) | Po | Pf | Pl | Ep |
|---|---|---|---|---|---|---|
| | | | kg/sq.cm | | | |
| Fill | - | 3.00 (BH-2) | 0.56 | 1.50 | >1.66 | 12 |
| Kenny Hill Formation | Medium to Stiff Sandy Silt | 4.00 (BH-1) | 2.60 | 9.32 | >12.22 | 156 |
| | Medium to Stiff Silty Clay | 5.00 | 0.68 | 1.60 | >2.49 | 21 |

Note: Po - Earth Pressure at Rest
Pf - Creep Pressure
Pl - Limit Pressure
Ep - Modulus of Deformation

(d) Groundwater Table

The water level measured in the boreholes during the period of the field work ranges from G.L. -0.90 to G.L. -2.60m. The portable groundwater levels in the boreholes monitored during the field work were G.L. -2.0m and G.L. -1.0m in BH-1 and BH-2 respectively.

(2) Klang River Bridge

(a) Topographic and Geological Outline

The site is located in Puchong area and the proposed bridge will be over the Klang river which flows through the area as shown in Figure 5.2.1. The western part of the site is almost a flat area, but on the other hand, the eastern part of the site is bounded by a hill, Bukit Tandang. On both sides of the river bank there are many wooden houses and a few factories.

As shown in Figure 5.2.1 the Geological Map, the site is located at the geological boundary between the Kuala Lumpur Limestone on the west and Kenny Hill Formation on the east. Many tin mines were located in the surrounding area of which most of them were already abandoned and some were used as sand quarry. Many old tin mining ponds in the vicinity of the site were reclaimed for housing development.

Residual soil and heavily weathered Kenny Hill Formation can be seen on the east, which form a hill, Bukit Tandang.

(b) Ground Conditions at Klang River Bridge

Two exploratory boreholes BH-1 and BH-2 were sunk to a depth of 14.39m and 13.25m from the ground surface respectively. The boreholes were located on both sides of the river bank as shown in Figure 5.2.1. The width of the river at the proposed bridge site was about 30m. The ground elevation at the boreholes location was about RL +16.0m.

Based on the results of the exploratory boreholes, a soil profile was prepared and shown in Figure 5.2.3.

As can be seen in the soil profile the subsurface ground at the site can be divided into 3 types of layers that is:-

(i) Fill
(ii) Alluvial
(iii) Kenny Hill Formation

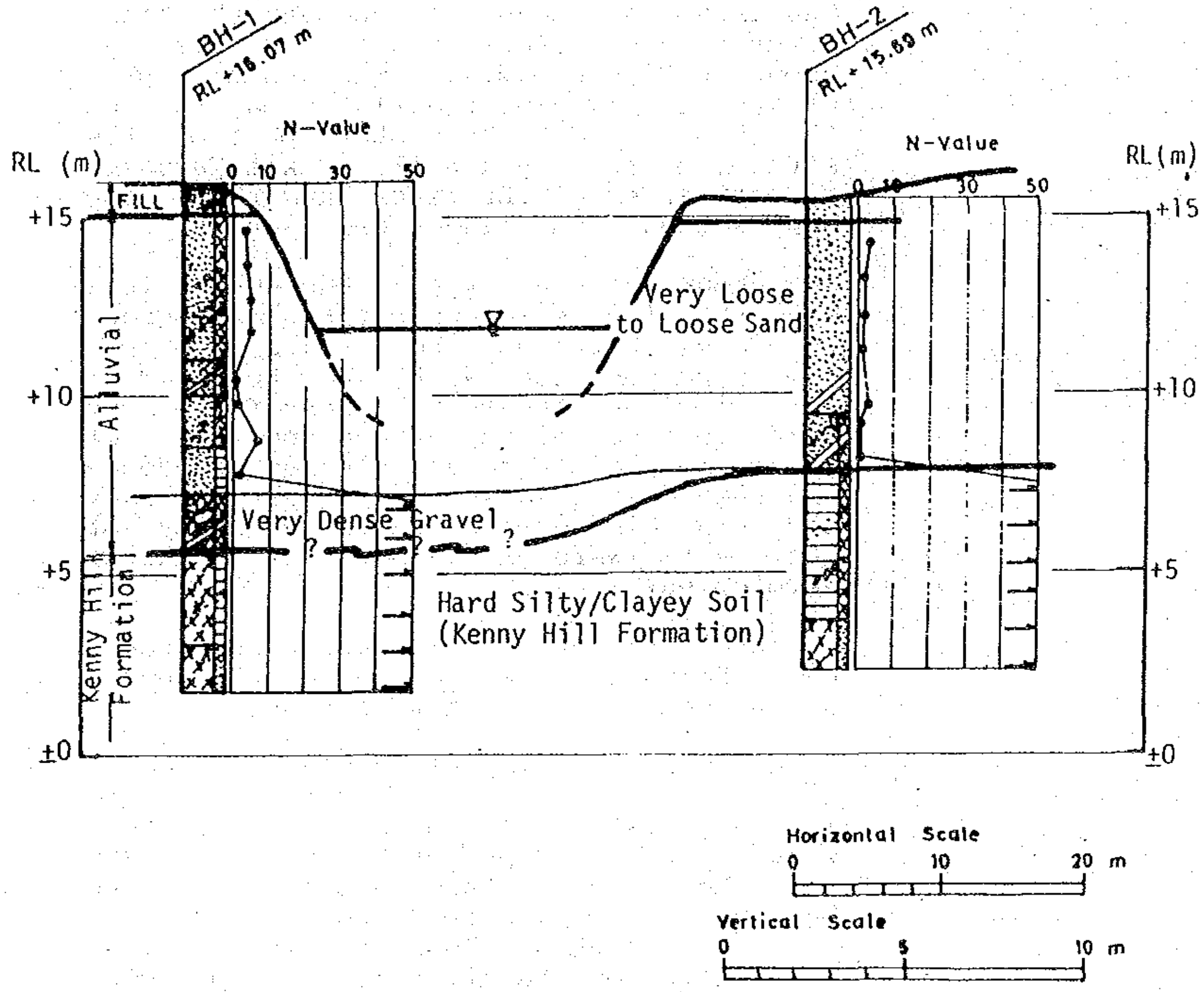



Figure 5.2.3: Soil Profile at Klang River Bridge Site

The engineering properties of each layer/stratum is presented in Table 5.2.3. No undisturbed soil sample was taken since there was no soft cohesive layer encountered.

(i) Fill

Fill consists of light brown to brownish grey sand with gravel and at BH-1 rubbish were also found in it. The thickness was about 1.0m at both boreholes location. The fill layer at BH-2 was recently laid by the nearby housing contractor to transport sand from a sand quarry located further south of the site for backfilling purpose.

(ii) Alluvial

It consists of 2 layers that is the sandy layer and gravelly layer. The sandy layer was encountered in both the boreholes. It consists of light brown to grey very loose to loose fine to coarse sand with gravels and pebbles and sometime organic matter, mica flakes and clay. The N-value ranges from 1 to 7. The thickness of this layer was about 8.0m in BH-1 and 7.0m in BH-2.

The gravely layer consists of light grey silty fine to coarse gravel with traces of clay. It was encountered in borehole BH-1 only underlying the sand layer. The N-values are more than 50. The thickness confirmed in borehole BH-1 was 1.70m.

The laboratory soil test performed on the sandy alluvial soil indicated a water content of about 15 to 33% and specific gravity of 2.619 to 2.656.

Table 5.2.3 Summary of Engineering Properties of Soil Strata at Klang River Bridge Site

| Formation | Strata | Thickness (m) | N-value | Grain Size Distribution (%) | | | | Water Content (%) | Specific Gravity | Wet Density (kN/m3) | Atterberg Limit (%) | | Cohesion (kN/m2) | Angle of Internal Friction | Preconsolidation Pressure (kN/m2) | Compression Index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Clay | Silt | Sand | Gravel | | | | Liquid Limit | Plastic Limit | | | | |
| Fill | | 1.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Alluvial | Very Loose to Loose Sand | 7.0 ~ 8.0 | 1 ~ 7 | 4 ~ 44 | | 54 ~ 61 | 0 ~ 38 | 15 ~ 33 | 2.619 ~ 2.656 | - | - | - | - | - | - | - |
| - | * Very Dense Gravel | 1.70 | > 50 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Kenny Hill Formation | Hard Silty/ Clayey Soil | > 5.0 | > 50 | - | - | - | - | - | - | - | - | - | - | - | - | - |

* Encountered in 1 borehole only

(iii) Kenny Hill Formation

The Kenny Hill Formation was encountered in both the boreholes underlying the alluvial. The formation was completely weathered but the sedimentary structures can still be observed.

It consists of hard grey to black silty and clayey soil with present of gravel sometimes. The N-values are typically more than 50. The elevation of the top surface of the formation was RL +5.57m in BH-1 and RL +7.70m in BH-2.

(c) Pressuremeter Test

The pressuremeter tests were carried out in the Very Loose to Loose Sand alluvial layer. The result of the tests are summarized in Table 5.2.4.

Table 5.2.4 : Summary of Pressuremeter Test Result at Klang River Bridge

| Formation | Strata | Depth (m) (BH) | Po Kg/cm2 | Pf Kg/cm2 | Pl Kg/cm2 | Ep Kg/cm2 |
|---|---|---|---|---|---|---|
| Alluvial | Very Loose to Loose Sand | 5.00 (BH-1) | 0.54 | 1.40 | >1.68 | 12.50 |
| | | 5.00 | 0.52 | 1.51 | >1.72 | 12.50 |

Po : Earth Pressure at Rest
Pf : Creep Pressure
Pl : Limit Pressure
Ep : Modulus of Deformation

(d) Groundwater Table

The water level measured in the boreholes during the period of the field work ranges from G.L. -1.40 to G.L. -4.45m. The probable groundwater levels in the boreholes monitored during the field work were G.L. -4.45m in BH-1 and G.L. -1.40m in BH-2.

(3) Subang West Interchange

(a) Topographic and Geological Outlines

The proposed interchange site is located near the Sime Darby Ebor research centre at 4km Puchong road about 20km south west of Kuala Lumpur city. It is situated in an oil palm plantation which form part of the Seafield Estate owned by Sime Darby.

The site is located in a undulating topography consisting of hilly areas on the west and south west and a relatively flat ground on the east. On the flat land there were several water treatment ponds for the rubber processing factory located nearby. The whole area of the site and the surrounding area was cultivated with oil palm.

As can be seen from the geological map in Figure 5.2.1 the site is located at the geological boundary of the Kenny Hill Formation and the Granite.

No fresh outcrop of both geological unit were encountered within the site except the completely weatheared Kenny Hill Formation observed in some of the cutting and excavation in the area.

(b) Ground Conditions at Subang West Interchange

Three exploratory boreholes BH-1, BH-2 and BH-3 were sunk to a depth of 6.04m, 34.37m and 11.15m respectively. The boreholes BH-1, BH-3 and the supplementary swedish sounding test SW-1 were located on a relatively flat area near to the water treatment pond with elevation range from RL +10.14 to RL +10.7m. On the other hand BH-2 was located on a relatively higher ground with elevation of RL +22.3m and separated from the former 2 boreholes by a hill ridge.

Based on the result of the field investigation a soil profile of the site was prepared and presented in Figure 5.2.4.

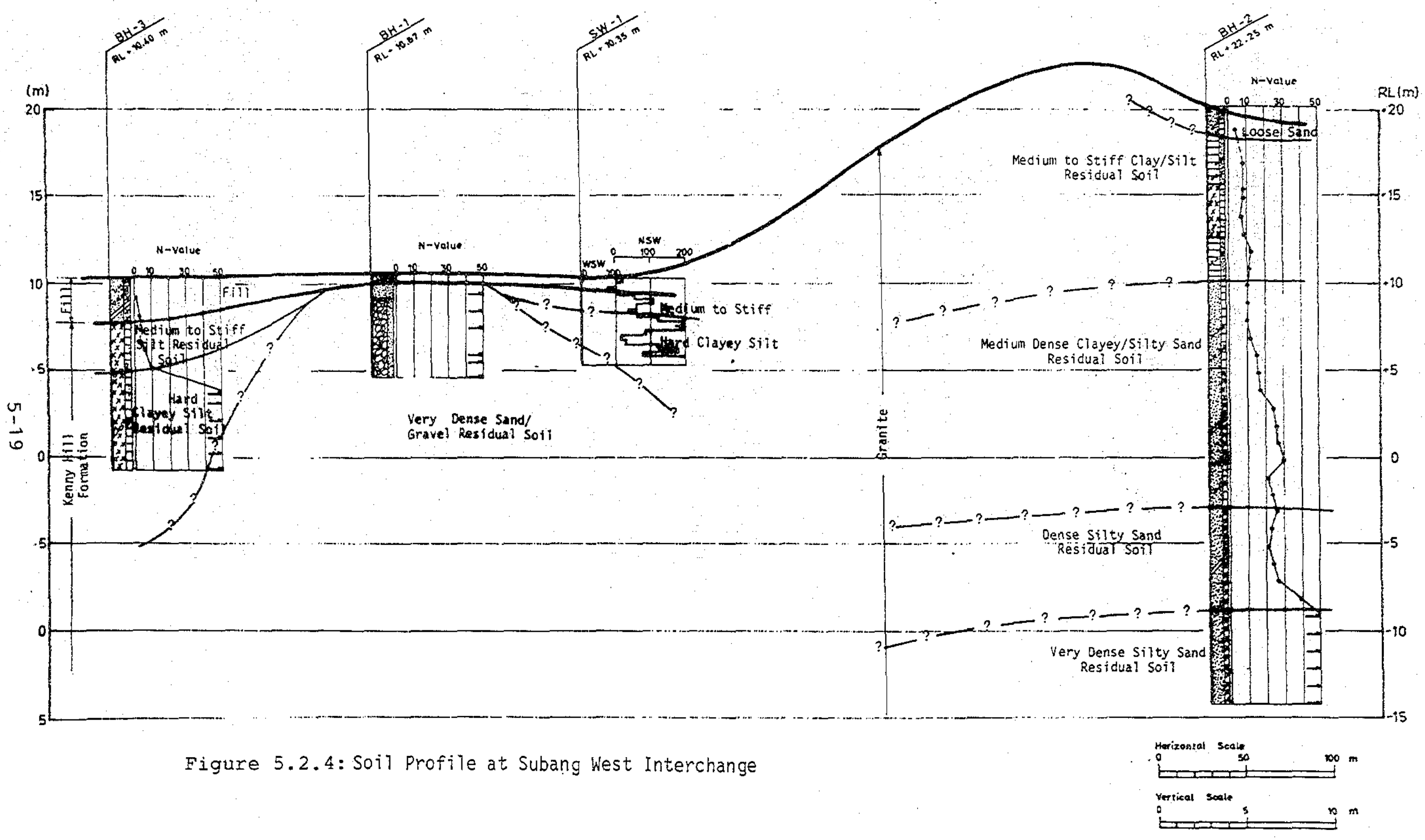



Figure 5.2.4: Soil Profile at Subang West Interchange

As can be seen in the soil profile the subsurface ground at the site can be classified into 3 layers as follows:-

(i) Fill
(ii) Granite Residual Soil
(iii) Kenny Hill Formation

The engineering properties of each formation and stratum are tabulated in Table 5.2.5.

(i) Fill

Fill was only encountered in the low ground area at borehole BH-1, BH-3 and Swedish Sounding test SW-1. The thickness of the fill varies from 2.20 to 0.6m and it is expected to be thicker at the pond area. It consists of light brown very loose to loose silty sand with some organic matter and gravel. The N-values are between 1 to 3. The fill soil at BH-3 and SW-1 is suspected to have been laid during the excavation of the water treatment pond.

(ii) Granite Residual Soil

Residual soil of granite was encountered in borehole BH-2 immediately below the ground surface. The boundary between the Kenny Hill Formation and the granite is not known, however it is suspected that the boundary lies in between the hill area and the relatively flat ground.

Based on the N-values and the type of soil encountered the formation can be further divided into 5 strata:-

- Loose Sand
- Medium to Stiff Clayey Silty Soil
- Medium Dense Sandy Soil
- Dense Sandy Soil
- Very Dense Sandy Soil

In general the N-values in the residual soil gradually increases with depth. At deeper portion sandy soil was the common soil encountered.

Table 5.2.5: Summary of Engineering Properties of Soil Strata at Subang West Interchange Site

| Formation | Strata | Thickness (m) | N-value | Grain Size Distribution (%) | | | | Water Content (%) | Specific Gravity | Wet Density (kN/m3) | Atterberg Limit (%) | | Cohesion (kN/m2) | Angle of Internal Friction | Preconsolidation Pressure (KN/m2) | Compression Index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Clay | Silt | Sand | Gravel | | | | Liquid Limit | Plastic Limit | | | | |
| * Fill | - | 0.6 ~ 2.20 | 1 ~ 3 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Granite (Residual Soil | * Loose Sand | 1.70 | 4 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | * Medium to Stiff Clayey/Silty Soil | 8.30 | 7 ~ 13 | 32 ~ 40 | 10 ~ 27 | 32 ~ 54 | 1 ~ 2 | 24 ~ 40 | 2.632 ~ 2.651 | ** 18.3 | 52 ~ 66 | 25 ~ 31 | ** 52 ~ 84 | - | ** 220 | ** 0.21 |
| | * Medium Dense Sandy Soil | 13.0 | 10 ~ 30 | 18 ~ 25 | 27 ~ 33 | 40 ~ 44 | 4 ~ 9 | 24 ~ 32 | 2.533 ~ 2.642 | - | 49 ~ 55 | 29 ~ 33 | - | - | - | - |
| | * Dense Sandy Soil | 6.0 | 21 ~ 39 | ** 18 | ** 29 | ** 39 | ** 14 | ** 23 | ** 2.627 | - | ** 47 | ** 29 | - | - | - | - |
| | * Very Dense Sandy Soil | > 5.0 | > 50 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| * Kenny Hill Formation | * Medium to Stiff Silty Soil | 0 ~ 3.0 | 4 ~ 10 | ** 24 | ** 37 | ** 27 | ** 12 | ** 47 | ** 2.665 | - | ** 59 | ** 34 | - | - | - | - |
| | * Hard Silty Soil | > 5.0 | > 50 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | * Very Dense Sandy/ Gravely Soil | > 5.0 | > 50 | - | - | - | - | - | - | - | - | - | - | - | - | - |

* Encountered in 1 borehole only.

** Tested on 1 sample only.

Only one undisturbed sampling was possible in this formation.

The water content tends to decrease with depth and with increases in sand content. The specific gravity typically range from 2.632 to 2.651. Consolidation test performed on one sample from the medium to stiff clayey soil shows a high preconsolidation pressure 220 KN/M and compression index of 0.21.

Loose Sand

It was about 1.70m thick and consist of reddish brown clayey sand. Sand was fine to coarse grained with some organic matter and rootlet. The N-value was 4.

Medium to Stiff Clayey/Silty Soil

The thickness was 8.30m and it consists of multiple colour of yellow, brown and creamy white sandy clay and clayey silt with lateritic gravel on the top portion of the layer. The N-value is quite consistent, it varies from 7 to 13.

Mediu Dense Sandy Soil

The thickness was 13.0m and it consists of multiple colour of creamy white, yellow and brown clayey and silty sand. Sand is fine to coarse grained. The N-value varies from 10 to 30.

Dense Sandy Soil

The thickness was about 6.0m and it consists of creamy white to light brown silty sand. Sand is fine to coarse grained with coarse grained is more prominent. The N-value varies from 21 to 39.

Very Dense Sandy Soil

The depth to this stratum from ground surface was about 29.0m. The thickness is expected to be more than 5m. It consists of same material as in the dense sandy soil.

(iii) Kenny Hill Formation

This formation was encountered at boreholes location BH-1, BH-3 and at Swedish Sounding location SW-1.

It was found underlying the fill layer. Typically it consists of dark grey to black completely to highly weathered shale rock. The distribution and the continuation of this formation was difficult to determine since the geological boundary between this formation and the granite could not be delineated.

In general the soil stratum within the Kenny Hill Formation can be further divided into 3 strata based on the soil type and N-value:-

- Medium to Stiff Silty Soil
- Hard Silty Soil
- Very Dense Sandy/Gravely Soil

Laboratory soil test was performed on only one disturbed sample that is in the medium to stiff silty soil due to no significant soft layer and encountered.

Medium to Still Silty Soil

This stratum was only encountered in borehole BH-3 and swedish sounding location SW-1, basically at area near the water treatment pond. It consists of grey to black completely weathered shale. The thickness varies from about 3 to less than 1m. The stratum thickness is expected to be thicker at the margin of the existing pond, elsewhere it is expected to be thinner say less than 1.0m. The N-values vary from 4 to 10 with water content of about 47% and specific gravity of 2.665.

Hardy Silty Soil/Very Dense Sandy/ Gravely Soil

The depth to these hard or very dense strata is expected to be less than 6m at the pond area and much more shallower elsewhere within the site area. Sometime these strata lie immediately below the existing ground surface as in BH-1. It consists of typically grey to black heavily weathered shale with N-values are more than 50 blows.

(c) Pressuremeter Test Result

The pressuremeter tests were carried out in the Medium to Stiff Clay/Silt stratum of the Granite residual soil and in the Medium to Stiff Silty Soil and Hard and Very Dense Soil of the Kenny Hill Formation. The results are summarized in Table 5.2.6.

Table 5.2.6 : Summary of Pressuremeter Test Result at Subang West Interchange

| Formation | Strata | Depth (m) (BH) | Po Kg/cm2 | Pf Kg/cm2 | Pl Kg/cm2 | Ep Kg/cm2 |
|---|---|---|---|---|---|---|
| Granite (Residual Soil) | Medium to Stiff Clay/ Silt | 4.00 (BH-2) | 1.70 | 3.70 | >6.45 | 62.6 |
| Kenny Hill Forma- tion | Medium to Stiff Silty Soil | 3.00 (BH-3) | 0.19 | 0.72 | >1.02 | 11.7 |
| | Hard Silty Soil | 4.00 (BH-1 | 2.90 | 18.05 | - (Blow out) | 781 |
| | Very Dense Soil | 6.00 (BH-1) | 3.60 | 7.45 | >10.85 | 199 |

Po : Earth Pressure at Rest
Pf : Creep Pressure
Pl : Limit Pressure
Ep : Modulus of Deformation

(d) Groundwater Table

At location BH-1 and BH-3, the water level in the boreholes range from GL -0.0 to GL -1.50m and at location BH-2, it ranges from GL -1.30 to GL -1.80m.

The probably groundwater level monitored in the boreholes during the field work were G.L. 0.0m in BH-1, G.L. -1.50m in BH-3 and G.L. -1.10m in BH-2.

(4) Bangi West Junction

(a) Topographic and Geological Outlines

The proposed site is located at about 25km of the existing Kuala Lumpur-Seremban Expressway, north west of Bangi Town.

The site is located in undulating topography, with relatively higher ground on the south west of the site area. Located on the east of the site is the Bangi Industrial area and on the west is a rubber estate.

As can be seen in the geological map in the Figure 5.2.1 the site is located in an area entirely underlying by the Kajang Formation. Completely weathered soil of the formation can be observed especially at the road cutting in the area.

There were also a few tin mines located in the Kajang Formation area. All the tin mines were already abandoned and some of the mining ponds can be seen in the Bangi area.

It is suspected that the tin mining operation was done in the rich tin bearing alluvial layer overlying the Kajang Formation and it is expected that a few isolated thick alluvial layer may be present in the area.

(b) Ground Conditions at Bangi West Junction

Two exploratory boreholes BH-1 and BH-2 were sunk to a depth of 15.34m and 29.37m, from ground surface respectively. Borehole BH-1 was located in the north part of the Bangi Industrial Area with ground elevation of RL +28.82m. BH-2 was located on the east side of the Expressway in an old plantation estate with the ground elevation is relatively higher about RL +36.6m. The area at the east of this borehole is rather swampy.

Based on the result of the exploratory boreholes a soil profile of the site was prepared and presented in Figure 5.2.5. From the soil profile the subsurface ground at the site can be classified into 3 formation as follows:-

(i) Fill
(ii) Alluvial
(iii) Kajang Formation

The engineering properties of each formation and stratum is shown in Table 5.2.7.

(i) Fill

It was encountered in both of the boreholes with thickness of 2.50m and 1.70m in BH-1 and BH-2. It consists of soft to very stiff greyish to yellowish brown clayey silt from the cut soil of the Kajang Formation. The N-value in BH-1 ranges from 17 to 23 while in BH-2 was 3.

(ii) Alluvial

Alluvial was only encountered in borehole BH-2 only and it underlies the fill. The total confirmed thickness of the alluvial was about 22m. It consists of alternates of clayey and sandy soil strata with varying consistency and density.

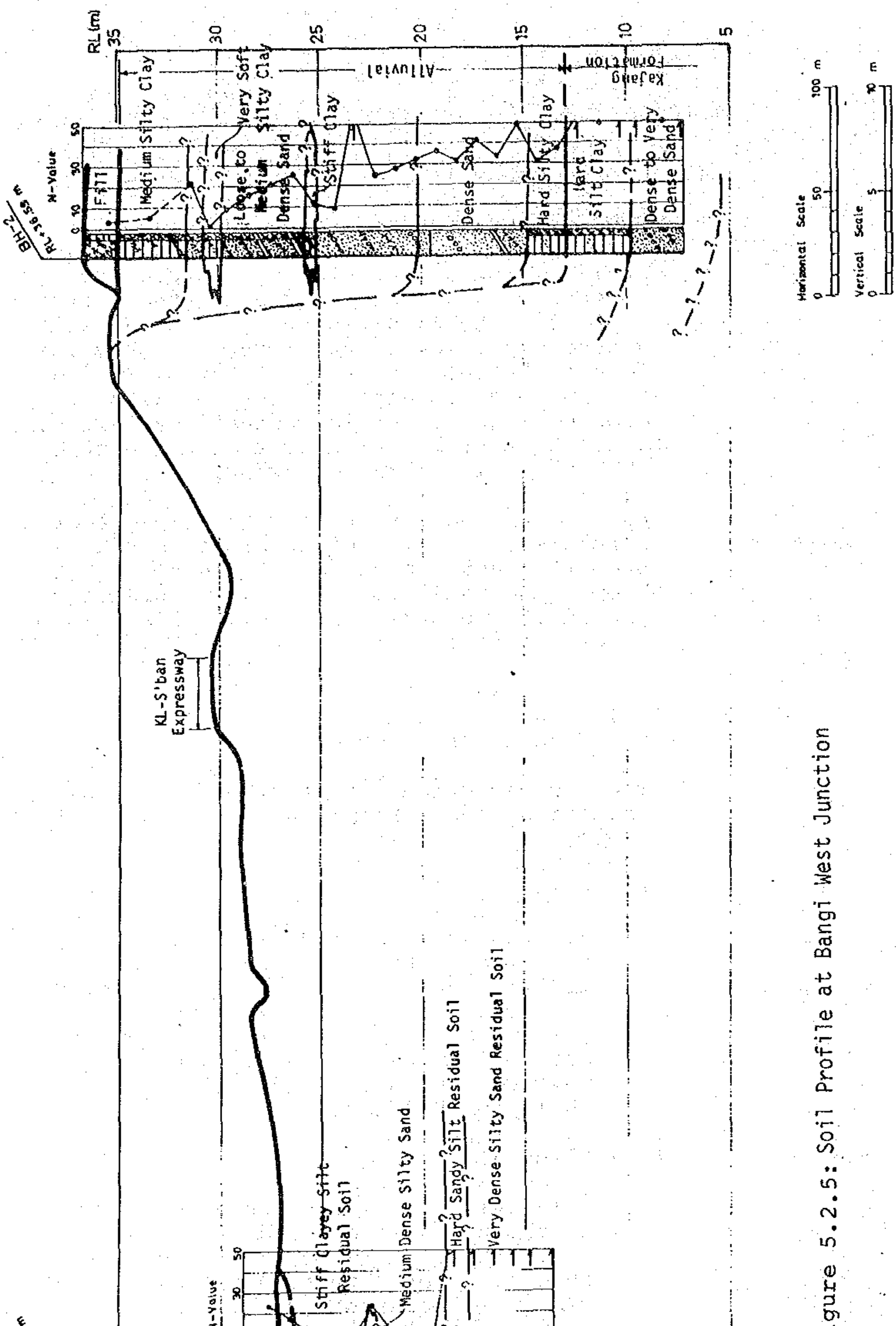



Figure 5.2.5: Soil Profile at Bangi West Junction

Table 5.2.7: Summary of Engineering Properties of Soil Strata at Bangi West Junction

| Formation | Strata | Thickness (m) | N-value | Grain Size Distribution (%) | | | | Water Content (%) | Specific Gravity | Wet Density (kN/m3) | Atterberg Limit (%) | | Cohesion (kN/m2) | Angle of Internal Friction | Preconsolidation Pressure (KN/m2) | Compression Index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Clay | Silt | Sand | Gravel | | | | Liquid Limit | Plastic Limit | | | | |
| Fill | | 1.70 ~ 2.50 | 3 ~ 23 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| * Alluvial | * Medium Silty Clay | 3.30 | 5 | ** 66 | ** 29 | ** 5 | ** 0 | ** 42 | ** 2.575 | ** 16.9 | ** 66 | ** 29 | ** 43 | ** 0° | ** 270 | ** 0.40 |
| | * Loose to Medium Dense Sand | 10.60 | 9 ~ 32 | 8 ~ 18 | | 43 ~ 62 | 22 ~ 49 | 11 ~ 13 | 2.645 ~ 2.656 | - | - | - | - | - | - | - |
| | * Dense Sand | 4.80 | 31 ~ 50 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | * Hard Silty Clay | 2.0 | 31 ~ 37 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Kajang Formation | * Stiff Silty Soil | 6.4 | 7 ~ 11 | 32 ~ 41 | 47 ~ 65 | 3 ~ 11 | 0 ~ 1 | 37 ~ 40 | 2.711 ~ 2.728 | - | 44 ~ 54 | 23 ~ 29 | - | - | - | - |
| | Hard Silty and Clay Soil | 1.2 ~ 3.1 | > 50 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Dense to Very Dense Sandy Soil | > 5.0 | > 50 | - | - | - | - | - | - | - | - | - | - | - | - | - |

* Encountered in 1 borehole only.

** Test on 1 sample only.

Based on the N-values and the type of soil encountered in the borehole BH-2, the formation can further be divided into 4 main typical soil strata:-

- Medium Silty Clay
- Loose to Medium Dense Sand
- Dense Sand
- Hard Silty Clay

Medium Silty Clay

The stratum is the top most portion of the alluvial and it consists of light grey silty clay with a lot of decayed vegetation and organic matter. The confirmed thickness was 3.30m.

The only N-value recorded is 5. Consolidation test on a sample from this strata show a high preconsolidation pressure of 270 KN/M and compression index of 0.40.

Loose to Medium Dense Sand

It consists of light grey to brownish grey sand and silty sand layer. Sand is fine to coarse grained, with the top portion of this stratum consists of decayed wood and vegetation. Fine to coarse sub-rounded gravels were also present. The thickness of this stratum was about 10.60m. the N-value typically varies from 9 to 32.

Within this sandy stratum, relatively thin layer of Very Soft and Stiff Clayey layer existed. The thickness of the very soft and stiff layer were only 0.9m and 0.6m respectively.

Dense Sand

It consists of whitish grey to greyish brown fine to coarse sand. Ocassionally with traces of clay, fine to coarse gravel and organic matter. The thickness was 4.80m with N-value varies from 31 to 50.

Hard Silty Clay

It formed the bottom stratum of the alluvial encountered in BH-2. It consists of light grey silty clay. The thickness is about 2m with N-value varies from 31 to 37.

(iii) Kajang Formation

The formation was completely weathered. It consists of multiple coloured of composite soil type varying from clayey to sandy soil.

The Kajang Formation was encountered in both the boreholes. In BH-1 it underlies the fill and in BH-2 it underlies the alluvial. The N-value in the Kajang Formation is typically more than 10. No soft layer was encountered in the formation.

Based on the soil type and the N-value the formation can be classified into 3 typical strata as follows:-

- Stiff Silty Soil
- Hard Silty and Clayey Soil
- Dense to Very Dense Sandy Soil

Stiff Silty Soil

It consists of multiple colour of red, yellow, pink and brown clayey silt. The thickness was about 6.4m confirmed in BH-1. The N-value varies from 7 to 11 with typical value of 10.

Within this stratum exist a relatively thin layer of about 1.0m medium dense silty sand.

Hard Silty and Clayey Soil

The silty stratum was encountered in borehole BH-1 underlying the iii (a) stratum with a thickness of 1.20m and N-value of more than 50. It consists of multiple colour sandy silt soil.

On the other hand the clayey stratum was encountered in borehole BH-2 underlying the alluvial with a thickness of 3.1m and N-value typically more than 50. It consists of multiple colour of silty clay soil.

Dense to Very Dense Sandy Soil

This stratum formed the bottom part of the Kajang Formation within the investigated depth in both the boreholes. It is suspected that the sand stratum in the BH-1 and BH-2 may be derived from different types of parent rock of the Kajang Formation.

The elevation to the top surface of the stratum in borehole BH-1 was at RL +13.48m while in BH-2 it was at RL +26.80m. The N-value of the stratum was more than 50.

(c) Pressuremeter Test

The pressuremeter tests were carried out in the Medium Silty Clay stratum of the Alluvial and the Stiff Silty stratum of the Kajang Formation. The test results are summarized in Table 5.2.8.

Table 5.2.8 : Summary of Pressuremeter Test Result at Bangi West Interchange

| Formation | Strata | Depth (m) (BH) | Po Kg/cm2 | Pf Kg/cm2 | Pl Kg/cm2 | Ep Kg/cm2 |
|---|---|---|---|---|---|---|
| Alluvial | Medium Silty Clay | 4.50 (BH-1) | 0.24 | 0.97 | >1.28 | 8 |
| Kajang Formation | Stiff Silty Soil | 4.00 (BH-2) | 1.28 | 4.75 | >5.89 | 136 |

Po : Earth Pressure at Rest
Pf : Creep Pressure
Pl : Limit Pressure
Ep : Modulus of Deformation

(d) Groundwater Table

The water levels measured in the boreholes during the period of the field work are shown below:-

At location BH-1, ranges from GL -2.30 to 4.90m

At location BH-2, ranges from GL -1.20 to 1.30m

The probable groundwater levels monitored during the field work were G.L. -3.70m in BH-1 and G.L. -1.30m in BH-2.

(5) Klang West Interchange

(a) Topographic and Geological Outline

The proposed interchange site is located near the coastal area facing the straits of Malacca about 45km west of Kuala Lumpur.

Passing through the site is the existing Rantau Panjang road. Located very close on the north of the site is Sungai Che Awang which is one of the Sungai Kelang tributaries.

Many rivers are found in the alluvial plain located along the coastal area and usually mangrove swamps developed along these rivers. The site is situated in one of these mangrove swamp area.

Quaternary deposits are found extensively along the coastal area and it consists of unconsolidated alluvial layer. In general the alluvial layer along the coastal area consist of Estuarine, Marine and Fluviatile sediment. The thickness of this alluvial layer may sometimes exceed 70m.

(b) Ground Conditions at the Klang West Interchange

Two exploratory boreholes were sunk to about 45m deep. The boreholes were located on both sides of the Rantau Panjang road. The ground elevation at the boreholes' locations vary from RL +2.07m in BH-1 to RL +3.17m in BH-2 while the road level at the site was about RL +3.7m.

Based on the N-value and the sedimentary environment, the subsurface soil within the investigated depth can be divided into 9 typical strata as shown in the soil proficle in Figure 5.2.6 and is tabulated in Table 5.2.9.

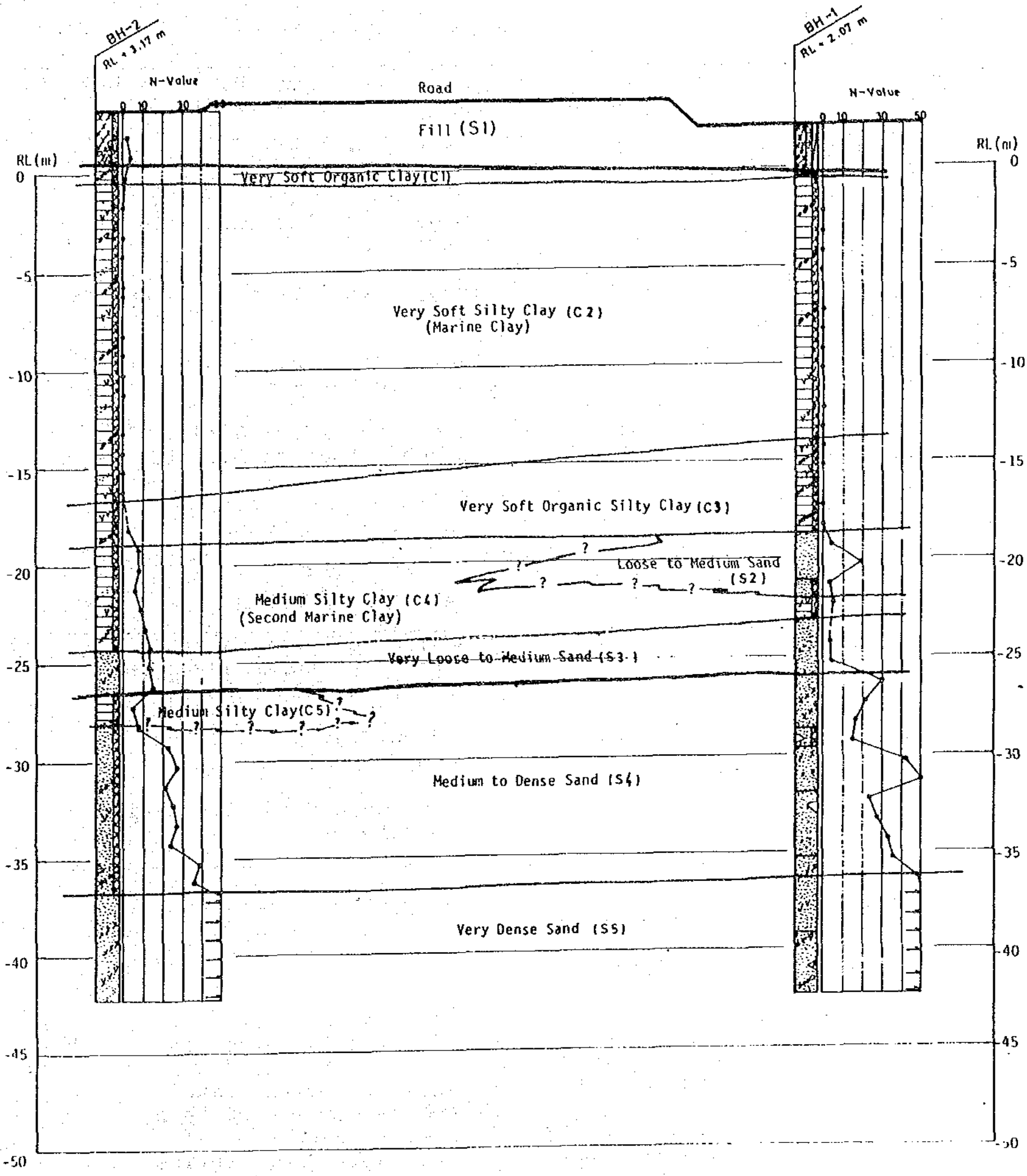



Figure 5.2.6: Soil Profile at Klang West Interchange

Table 5.2.9 : Subsurface Soil of the Site

| Formation | Geological Age | Symbols Used | Description of stratum (Strata) |
|---|---|---|---|
| Fill | | S1 | Soft Silty Soil, Fill |
| Alluvial | | C1 | Very Soft Clayey Soil with Organic Matter, Estuatine Deposits |
| | | C2 | Very Soft Clayey Soil, Marine Clay |
| | | C3 | Very Soft Clayey Soil with Organic Matter |
| | | S2 | Loose to Medium Sandy Soil, Beach/Estuarine Deposits |
| | | C4 | Medium Clayey Soil, Marine to Estuarine Deposits |
| | | S3 | Loose to Medium Sandy Soil Estuarine Deposits |
| | | S4 | Medium to Dense Sandy Soil with Clay lenses and seams. Fluviatile Deposits. |
| | | C5 | Medium Clayey Soil. Back Swamp Deposits |
| | | S5 | Very Dense Sand, Fluviatile Deposits |

The engineering properties of each soil stratum are presented in Table 5.2.10.

*Fill (S1)*

The fill covers the whole site with thickness of 2.40 and 2.70m in boreholes BH-1 and BH-2 respectively. It consists of reddish brown Soft Sandy Silt with gravel. Occasionally at the bottom portion of this fill contained some organic matters. The N-value measured in borehole BH-1 varies from 2 to 4.

Table 5.2.10: Summary of Engineering Properties of Soil Strata at Klang West Interchange

| Formation | Strata | Thickness (m) | N-value | Grain Size Distribution (%) | | | | Water Content (%) | Specific Gravity | Wet Density (kN/m3) | Atterberg Limit (%) | | Cohesion (kN/m2) | Angle of Internal Friction | Preconsolidation Pressure (KN/m²) | Compression Index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Clay | Silt | Sand | Gravel | | | | Liquid Limit | Plastic Limit | | | | |
| Fill | Soft Silty Soil (S1) | 2.40 ~ 2.70 | 2 ~ 4 | ** 45 | 19 | 29 | 7 | 28 | 2.711 | - | 48 | 20 | - | - | - | - |
| Alluvium | Very Soft Clayey Soil with organic (C1) | 0.30 ~ 0.90 | < 1 | - | - | - | - | ** 87 | - | - | ** 120 | ** 58 | - | - | - | - |
| | Very Soft Marine Clay (C2) | 13.30 ~ 16.30 | 0 | 50 ~ 71 | 27 ~ 48 | 1 ~ 4 | 0 | 73 ~ 131 | 2.610 ~ 2.644 | 13.6 ~ 15.1 | 103 ~ 139 | 35 ~ 58 | 9 ~ 36 (Cu=2.5z) | 0 0 | 28 ~ 120 | 1.19 ~ 1.81 |
| | Very Soft Clayey Soil with organic (C3) | 2.20 ~ 4.80 | 0 ~ 3 | 45 ~ 61 | 33 ~ 38 | 6 ~ 18 | 0 | 56 ~ 69 | 2.578 ~ 2.599 | 15.4 ~ 15.6 | 103 ~ 119 | 35 ~ 51 | 38 ~ 53 (Cu=2.5) | 0 0 | 140 ~ 185 | 0.36 ~ 1.11 |
| | * Loose to Medium Sandy Soil (S2) | 3.30 | 4 ~ 19 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Medium Clayey Soil (C4) | 1.10 ~ 5.30 | 5 ~ 14 | ** 67 | ** 32 | ** 1 | ** 0 | 22 ~ 40 | ** 2.617 | - | 36 ~ 55 | 17 ~ 26 | - | - | - | - |
| | Very Loose to Medium Sandy Soil (S3) | 2.0 ~ 3.0 | 3 ~ 15 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Medium to Dense Sandy Soil (S4) | 9.0 ~ 11.0 | 20 ~ 40 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | * Medium Clayey Soil (C5) | 1.50 | 5 | ** 54 | ** 43 | ** 3 | ** 0 | ** 43 | ** 2.647 | - | ** 72 | ** 26 | - | - | - | - |
| | Very Dense Sand (S5) | > 5.0 | > 50 | - | - | - | - | - | - | - | - | - | - | - | - | - |

* Encountered in 1 borehole only.
** Test on 1 sample only.

Alluvial

C1, C2 and C3 Very Soft Clayey Soil

The total thickness of these strata was about 18 to 20m and it underlies the fill layer. The top stratum C1 and the bottom stratum C3 contain relatively a lot of organic fragment. While the middle stratum C3 which is a marine clay has relatively less organic fragment and was judged to have accumulated away from the coastal area in the sea. The marine clay usually contains many seams of very fine sand and coarse silt.

The clayey soil are very weak and higly compressible. The undrained shear strength (Cu) increases with depth (z). The relationship between Cu and z in these clayey soil at the site may be expressed by the following equation:-

$$Cu = 2.5z$$

Preconsolidation pressure ( $\delta$ 'p) is slightly higher than the calculated effective overburden pressure. However, consolidation settlement due to the fill seems to be in progress at least in the surface of the stratum.

S2 Loose to Medium Sandy Soil

This stratum was only confirmed in BH-1 with the thickness of about 3.5m. It consists of fine to medium grained sand with muscovite present. The N-value varies from 4 to 19.

C4 Medium to Stiff Clayey Soil

This stratum is generally called as the second marine clay. It was encountered in both the boreholes with thickness of about 1m in BH-1 and about 5m in BH-2. The elevation of the bottom boundary of this stratum was between RL -23m to -24m. The typical range of the N-value was 5 to 14.

From laboratory soil test result it seem that there was discontinuity in term of the strength and consolidation characteristic between this stratum and C2 stratum.

S3 Very Loose to Medium Sandy Soil

This stratum consists of whitish grey to light brown fine to coarse sand and was encountered in both the boreholes. The thickness in the boreholes varies from about 2 to 3m. The N-values recorded vary from 3 to 15.

S4 Medium to Dense Sandy Soil

This sandy stratum may form the top of the older Quaternary formation that is the Pleistocene deposits and was distributed at the entire site. It consists of fine to coarse grained sand with some gravel and frequently with organic matter and clay seam. The thickness were about 9m and 11m as encountered in BH-2 and BH-1 respectively. The N-value typically ranges from 20 to 40. Due to the present of clayey seam the N-values in BH-1 area largely variable with depth compared to BH-2.

C5 Medium Clayey Soil

It was only confirmed in borehole BH-2 with the thickness of 1.50m. It consists of greenish grey silty clay with traces of fine sand. The N-value recorded was 5.

S5 Very Dense Sand

This stratum are distributed at the entire area of the site. The elevation to the top surface of the layer was about RL =36m to RL -37m in boreholes BH-1 and BH-2. The material was almost the same as S4 were more than 50.

(c) Pressuremeter Test

The pressuremeter tests were carried out in BH-2 the Very Soft Clayey Soil C1 and the results are summarized in Table 5.2.11.

Table 5.2.11 : Summary of Pressuremeter Test Result at Klang West Interchange

| Formation | Strata | Depth (m) (BH) | Po Kg/cm2 | Pf Kg/cm2 | Pl Kg/cm2 | Ep Kg/cm2 |
|---|---|---|---|---|---|---|
| | Very Soft Clayey Soil (C1) | 4.0 (BH-2) | 0.37 | 1.19 | >1.34 | 12.3 |
| | | 8.0 (BH-1) | 0.21 | 0.95 | >1.49 | 26 |

Po : Earth Pressure at Rest
Pf : Creep Pressure
Pl : Limit Pressure
Ep : Modulus of Deformation

(d) Groundwater Table

The water level measured in the boreholes during the period of the field work ranges from G.L. -0.50 to G.L. -1.50m. The probable groundwater levels monitored during the field work were G.L. -0.52m in BH-1 and G.L. -1.15m in BH-2.

(6) New Klang Valley Junction

(a) Topographic and Geological Outline

The proposed interchange site is located about 20km west of Kuala Lumpur city and about 2km north of the Shah Alam Batu Tiga junction near the Montfort Training Centre and Boy's Home. The ground elevation in the vicinity of the site is almost flat with elevation about RL +5.0m except at the existing road on the east and a new road under construction on the west.

Passing through the site is the Damansara river which usually will overflow during the heavy rainy days. This causes the area to be a flood-prone area during heavy rain especially at location BH-2. The flood water is sometime as high as 0.5m as can be seen in the photographs presented in the progress report.

The geological map of the site as shown in Figure 5.2.1 shows that the underlying formation in the area is expected to be Kenny Hill Formation. Alluvial deposit is expected to be found along the Damansara river. The thickness of the deposit usually ranges from a few metres to sometime more than tens of metres.

(b) Ground Conditions at New Klang Valley Junction

Two exploratory boreholes were sunk to the depth of 33.60m in BH-1 and 15.19m in BH-2, from the ground surface at the site. The boreholes were located on both sides of the Damansara river. Borehole BH-1 is located in an oil palm plantation and BH-2 is located very near to the river bank.

Based on the results of the exploratory boreholes a soil profile was prepared and shown in Figure 5.2.7. As can be seen in the figure, the subsurface ground at the site can be broadly classified into the following 3 formations:-

(i) Alluvial
(ii) Kenny Hill Formation and
(iii) Limestone

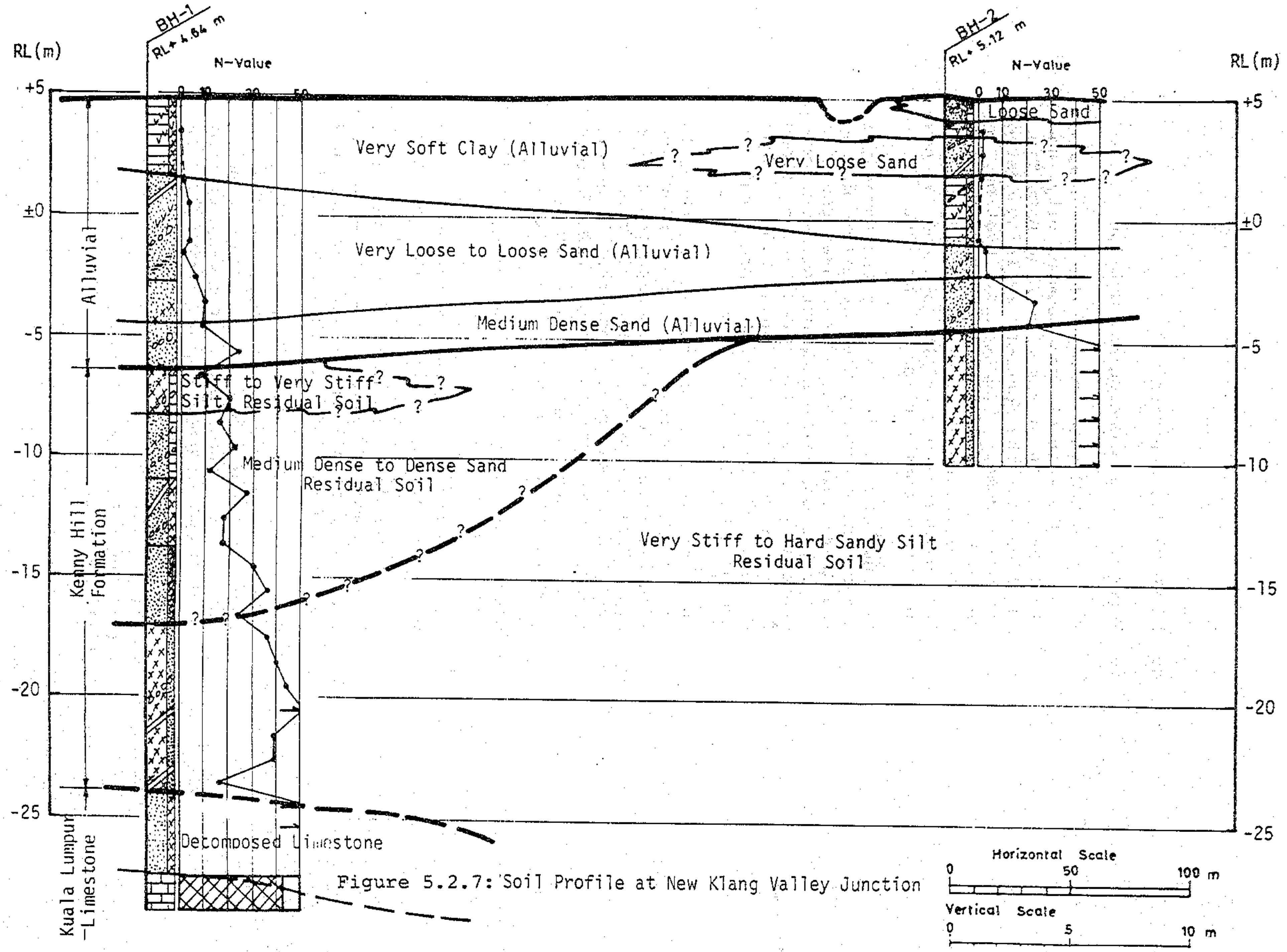



Figure 5.2.7: Soil Profile at New Klang Valley Junction

The engineering properties of each soil stratum is tabulated in Table 5.2.12.

(i) Alluvial

The alluvial formation can further divided into 5 strata based on the soil type and the N-values.

The 5 strata of the alluvial formations are as follows:-

- Very Soft Clay
- Loose Sand
- Very Loose Sand
- Very Loose to Loose Sand
- Medium Dense Sand

Very Soft Clay

This stratum was encountered in both the boreholes. It consists of dark brown to greyish brown silty clay with sand seam and a lot of organic matter. The thickness was about 3.0m. In BH-1 it was encountered immediately below the existing ground level and in BH-2 it underlies the loose sand stratum. The N-value was generally less than 1.

Loose Sand

This was a minor stratum of 90.9m thick and encountered only in BH-2 immediately below the existing ground surface. It consists of grey brown clayey sand of fine to coarse grained with gravel and organic matter.

Very Loose Sand

This stratum was encountered within the very soft clay layer. It was only encountered in BH-2 with thickness of 1.70m. It consists of brown to grey brown fine to coarse sand with a lot organic matter and some clay. The only recorded N-value was 2.

Table 5.2.12: Summary of Engineering Properties of Soil Strata at New Klang Valley Junction

| Formation | Strata | Thickness (m) | N-value | Grain Size Distribution (%) | | | | Water Content (%) | Specific Gravity | Wet Density (kN/m3) | Atterberg Limit (%) | | Cohesion (kN/m2) | Angle of Internal Friction | Preconsolidation Pressure (KN/m2) | Compression Index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Clay | Silt | Sand | Gravel | | | | Liquid Limit | Plastic Limit | | | | |
| Alluvial | Very Soft Clay | ≈ 3.0 | < 1 | 49 ~ 66 | 33 ~ 42 | 1 ~ 9 | 0 | 87 ~ 115 | 2.495 ~ 2.583 | 14.1 ~ 14.7 | 96 ~ 130 | 42 ~ 57 | 11 ~ 13 | 0° | 50 ~ 55 | 0.89 ~ 1.29 |
| | * Loose Sand | 0.9 | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | * Very Loose Sand | 1.70 | 2 | - | - | - | - | ** 32 | - | - | - | - | - | - | - | - |
| | Very Loose to Loose Sand | 1.0 ~ 6.0 | 3 ~ 10 | 2 ~ 5 | | 59 ~ 77 | 21 ~ 36 | 8 ~ 19 | - | - | - | - | - | - | - | - |
| | Medium Dense Sand | 1.50 ~ 2.0 | 21 ~ 24 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Kenny Hill Formation | * Stiff to Very Stiff Silty Soil | 1.90 | 8 ~ 20 | - | - | - | - | 35 | - | - | - | - | - | - | - | - |
| | * Medium Dense to Dense Sandy Soil | 8.80 | 12 ~ 36 | 20 ~ 38 | | 30 ~ 45 | 24 ~ 50 | 13 ~ 16 | - | - | - | - | - | - | - | - |
| | Very Stiff to Hard Silty Soil | ***(6.90) ; > 5.0 | 16 ~ >50 | ** 39 | ** 31 | ** 25 | ** 5 | ** 30 | ** 2.999 | - | ** 36 | ** 22 | - | - | - | - |
| * Limestone | Weathered Limestone | 3.00 | > 50 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Bedrock | > 1.50 | > 50 | - | - | - | - | - | - | - | - | - | - | - | - | - |

* Encountered in 1 borehole only.

** Test on 1 sample only.

*** ( ) Thickness in borehole BH-1

Very Loose to Loose Sand and Medium Dense Sand

These strata were encountered in both the boreholes with a total thickness of 8.0m in BH-1 and 3.50m in BH-2. It consists light grey to greyish brown and light brown fine to coarse sand with fine rounded gravel and some silt and organic matter. The N-value in the very loose to loose sand stratum varies from 3 to 10 and in the medium dense sand it was between 21 to 24.

(ii) Kenny Hill Formation

The Kenny Hill Formation is completely weathered. It is encountered beneath the alluvial layer. Based on the soil type and N-value this formation is further divided into 3 strata as follows:-

- Stiff to Very Stiff Silty Soil
- Medium Dense to Dense Sandy Soil
- Very Stiff to Hard Silty Soil

Stiff to Very Stiff Silty Soil

This soil stratum was only encountered in borehole BH-1 with the thickness of 1.90m. It consists of light grey to grey clayey silt with gravel size rock fragment and sand. The N-value was between 8 to 20.

Medium Dense to Dense Sandy Soil

This soil stratum was also encountered only in borehole BH-1 with the thickness of 8.80m. It consists of light grey to greyish black clayey, silty and gravelly sand. Sand is fine to coarse and the gravel consist of angular rock fragment. The N-value varies from 12 to 36.

Very Stiff to Hard Silty Soil

The soil stratum was encountered in both the boreholes with the thickness of 6.90m in BH-1 and the thickness is expected to be greater in BH-2. The N-value varies from 16 to 51m in BH-2 and greater than 50 in BH-2.

(iii) Limestone

This formation was only confirmed in borehole BH-1. The top surface of about 3.00m of this formation was completely weathered and decomposed into very dense greyish white silty sand. The sand was typically fine grained. The N-value in this decomposed soil was greater than 50.

Beneath the decomposed soil was the Kuala Lumpur Limestone bed rock. The depth to the limestone bed rock was about 32.0m from the ground surface at BH-1. The limestone is greyish white slightly weathered and with calcite veins. The RQD from coring was 85% indicating that it is a good quality rock.

(c) Pressuremeter Test

The pressuremeter tests were carried out in the Alluvial layer and the results are summarized in Table 5.2.13.

Table 5.2.13 : Summary of Pressuremeter Test Result at New Klang Valley Junction

| Formation | Strata | Depth (m) (BH) | Po Kg/cm2 | Pf Kg/cm2 | Pl Kg/cm2 | Ep Kg/cm2 |
|---|---|---|---|---|---|---|
| Alluvial | Very Soft Clay | 5.0 (BH-2) | 0.22 | 0.68 | >0.92 | 9.4 |
| | Very Loose to Loose Sand | 5.0 (BH-1) | 0.24 | 0.59 | >0.80 | 10 |

Po : Earth Pressure at Rest
Pf : Creep Pressure
Pl : Limit Pressure
Ep : Modulus of Deformation

(d) Groundwater Table

The water level measured in the boreholes during the period of the field work ranges from G.L. 0.0 to G.L. -1.2m. However as mentioned earlier during heavy rainy day the area at BH-2 is flooded with water about 0.5 above ground surface.

The probable groundwater levels monitored during the field work were G.L. -1.0m in BH-1 and G.L. -0.5m in BH-2.

(7) Kim Chuan Interchange

(a) Topographic and Geological Outline

The proposed interchange site is located at about 5km west of Klang Town along the Persiaran Raja Muda road at the junction of Kim Chuan road and Petola road. Topographically it is located near the coastal area facing the straits of Malacca. The ground level in the vicinity of the site is almost flat with ground elevation of about RL +2 to +3m.

Along this coastal area there are many broad alluvial plains and a large part of this plain, especially closer to the shore, mangrove swamp developed. Figure 5.2.1 shows the geological map of the site and its surrounding area. As can be seen in the geological map, the Kenny Hill Formation crops out further inland.

Quaternary deposits underlies the Kenny Hill Formation at the site and generally the thickness of the deposits may exceeds 70m at the site. In general the Quaternary deposits in the coastal area consists of unconsolidated Estuarine, Marine Fluviatile sediments and sometime a mixture of them.

(b) Ground Conditions at Kim Chuan Interchange

Two exploratory boreholes were sunk to the depth of 69.07 m and 60.29m from the ground surface in borehole BH-1 and BH-2 respectively. The ground elevation were RL +2.89m in BH-1 and RL +2.96m in BH-2.

To better understand the subsurface ground condition at the site a soil profile was prepared based on the drilling results as shown in Figure 5.2.8. As shown in the soil profile the subsurface ground consist of entirely the Alluvial deposits except the Fill at the surface. Based on the N-values and sedimentary environment, the subsurface soil within the investigated depth at the site the alluvial may be divided into 8 strata as shown in Figure 5.3.12 and as tabulated in Table 5.2.14.

Table 5.2.14 : Subsurface Soil of the Site

| Formation | Geological Age | Symbols Used | Description of stratum (Strata) |
|---|---|---|---|
| Fill | | S1 | Very Soft to Medium Clayey Soil, Fill |
| Alluvial | Recent | C1 | Very Soft Clayey Soil, Marine Clay |
| | | C2 | Very Soft to Stiff Clayey Soil, Second Marine Clay |
| | Pleistocene | S2 | Dense to Vey Dense Sandy Soil, Fluviatile Deposits |
| | | C3 | Stiff Clayey Soil, Estuarine Deposits |
| | | S3 | Medium Dense Sandy Soil, Fluviatile Deposits |
| | | C4 | Very Stiff to Hard Organic Silty Soil, Estuarine Deposits |
| | | S4 | Medium Dense to Very Dense Sandy Soil, Fluviatile Deposits |
| | | S5 | Very Dense Sandy Soil, Fluviatile Deposits |

The engineering properties of the soil strata are summarized in Table 5.2.15.

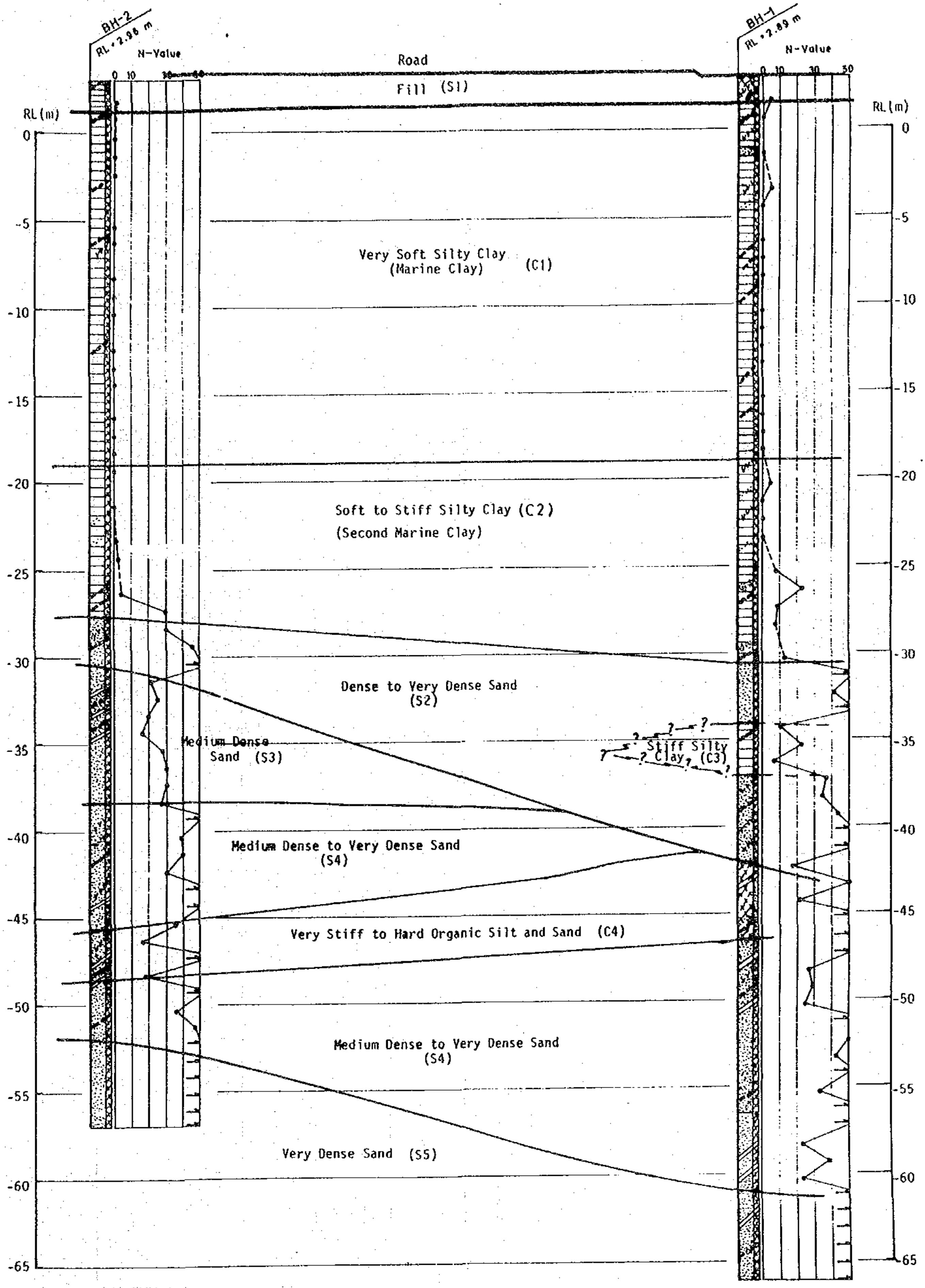



Figure 5.2.8: Soil Profile at Kim Chuan Interchange

Table 5.2.15: Summary of Engineering Properties of Soil Strata at Kim Chuan Interchange

| Formation | Strata | Thickness (m) | N-value | Grain Size Distribution (%) | | | | Water Content (%) | Specific Gravity | Wet Density (kN/m3) | Atterberg Limit (%) | | Cohesion (kN/m2) | Angle of Internal Friction | Preconsolidation Pressure (KN/m 2) | Compression Index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Clay | Silt | Sand | Gravel | | | | Liquid Limit | Plastic Limit | | | | |
| Fill | Very Soft to Medium Clayey Soil (S1) | 1.50 ~ 2.0 | 1 ~ 5 | ** 42 | ** 17 | ** 28 | ** 13 | ** 25 | ** 2.753 | - | ** 48 | ** 19 | - | - | - | - |
| Alluvium | Very Soft Marine Clay (C1) | 19.0 ~ 20.0 | 0 | 32 ~ 76 | 22 ~ 53 | 1 ~ 5 | 0 | 80 ~ 121 | 2.463 ~ 2.610 | 13.6 ~ 15.1 | 118 ~ 138 | 46 ~ 61 | 12 ~ 39 (Cu=8+1.6z) | φ 0 | 50 ~ 145 | 0.72 ~ 1.60 |
| | Very Soft to Stiff Clayey Soil (C2) | 9.0 ~ 12.0 | 0 ~ 13 | 45 ~ 66 | 33 ~ 55 | 0 ~ 4 | 0 | 33 ~ 67 | 2.509 ~ 2.689 | 15.7 ~ 18.5 | 64 ~ 97 | 23 ~ 38 | 34 ~ 77 (Cu=8+1.6z) | φ 0 | 180 ~ 360 | 0.29 ~ 1.01 |
| | Dense to Very Dense Sandy Soil (S2) | 3.0 ~ 8.0 | 30 ~ >50 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | * Stiff Clayey Soil (C3) | 3.0 | 7 ~ 23 | ** 37 | ** 48 | ** 11 | ** 4 | 41 ~ 45 | ** 2.531 | - | ** 66 | ** 29 | - | - | - | - |
| | * Medium Dense Sandy Soil (S3) | 8.0 | 20 ~ 30 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Very Stiff to Hard Organic Clay (C4) | 2.00 ~ 4.50 | 16 ~ >50 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Medium to Very Dense Sandy Soil (S4) | 9.0 ~ 15.0 | 24 ~ >50 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | Very Dense Sandy Soil (S5) | > 5.0 | > 50 | - | - | - | - | - | - | - | - | - | - | - | - | - |

* Encountered in 1 borehole only.

** Test on 1 sample only.

S1 Fill

Fill cover the entire site with thickness about 1.50 to 2m. Fill material consist of very soft to medium clayey soil occassionally with gravel and organic matter. The N-value measured varies from 1 to 5. The physical properties from laboratory test performed on one disturbed sample of the fill indicated a water content of 25% and specific gravity of 2.753.

Alluvial

C1 Very Soft Clayey Soil

In general it is known as the marine clay. It consists of grey colour silty clay with sea shell fragment, seam of fine sand and silt, organic matter and decayed wood. Organic matter and decayed wood are present at certain particular depth only. The thickness of this stratum at the site was about 19 to 20m.

the present of organic matter regularly in this marine clay strata suggested that is may has been accumulated in the sea very close to the source of this organic matter such as near the coast or river mouth.

This very soft silty clay are considerably very weak and highly compressible. The undrained shear strength (Cu) of the soil can be expressed int he following equation.

$$Cu\ (kN/M2) = 8 + 1.6z$$

where z is the depth in meter.

The preconsolidation pressure ( $\delta$ 'p) is slightly higher to the calculated effective overburden pressure. Due to the present of silt and fine sand seams in this stratum, coefficients of consolidation may sometime be higher than those of typical marine clay.

C2 Very Soft to Stiff Clayey Soil (Second Marine Clay)

In general this stratum is known as the second marine clay. It was encountered in both the boreholes and found underlying directly below the C1 stratum. The thickness of the stratum was about 9 to 12m. The typical range of the N-values wre 0 to 13.

The laboratory test result performed on this stratum shows that no discontinuity seem to exist between the C1 clayey soil and this soil stratum (C2) in terms of their strength and conslidation characteristic. However, the water content shows a decrease in value and an increase in wet density in this strata compared to C1 strata.

S2 Dense to Very Dense Sandy Soil

This sandy strata may form the top of the older formation of the Quarternary that is the Pleistocene deposits. The elevation of the surface of the stratum varies from RL -28 to RL -31m.

It consists of whitish to greyish brown and brown silty sand. Sand is fine to coarse with decayed wood and organic matter. The thickness was about 3m in BH-2 and about 8m in BH-1. The N-value ranges from 30 to greater than 50.

C3 Stiff Clayey Soil

This clayey soil was only encountered in BH-1 with thickness of 3m. It was distributed within the S2 stratum. The N-values vary from 7 to 23. The laboratory physical property test indicated a water content of between 41 to 46% and specific gravity of 2.531.

S3 Medium Dense Sandy Soil

This sandy stratum was only found in borehole BH-2 with thickness of about 8m. It consists of greyish brown silty sand with some decayed wood and clay seam. The N-values are quite consistant typically vary from 20 to 30.

C4 Very Stiff to Hard Organic Silty and Sandy Soil

The stratum was encountered in both the boreholes. It consists of dark brown to black sandy and silty soil with a lot of organic matter and decayed wood.

In borehole BH-1, it underlies the S2 stratum while in BH-2 it was found inbetween the Medium Dense to Very Dense Sandy Soil, (S4) stratum. The thickness in the boreholes were about 5m. The N-values greatly vary from 16 to more than 50.

S4 Medium Dense to Very Dense Sandy Soil

It was distributed in both the boreholes with thickness varies from about 9 to 15m. It consists of whitish brown to greyish white silty sand. Sand is fine grained with clay seam and some organic matter. The depth from ground level to this stratum wre 49.50 and 42m inBH-1 and BH-2 respectively. The N-values vary greatly from 24 to more than 50.

S5 Very Dense Sandy Soil

This sandy soil formed the basic stratum of the alluvial deposits within the investigated depth. The elevation of the top surface of this stratum was RL -64.00 in BH-1 and RL -55.00 in BH-2.

The stratum consist of typically the same material as S4 but the present of clay seam and organic matter are less frequent or none. Only 5m of the stratum was confirmed with N-values greater than 50.

(c) Pressuremeter Tests

The pressuremeter tests were carried out in the Very Soft Silty Clay (C1) stratum of the alluvial. The depth of testing and test results are summarized in Table 5.2.16.

Table 5.2.16: Summary of Pressuremeter Test Result at Kim Chuan Interchange

| Formation | Strata | Depth (m) (BH) | Po Kg/cm2 | Pf Kg/cm2 | P1 kg/cm2 | Ep Kg/cm2 |
|---|---|---|---|---|---|---|
| Alluvial | Very Soft Silty Clay (C1) | 5.0 (BH-1) | 0.27 | 0.89 | >1.31 | 15.3 |
| | | 7.5 (BH-1) | 0.18 | 0.40 | >0.75 | 11.0 |

Po : Earth Pressure at Rest
Pf : Creep Pressure
P1 : Limit Pressure
Ep : Modulus of Deformation

(d) Groundwater Table

The water level measured in the boreholes during the period of the field work ranges from G.L. -0.50 to G.L. -2.90m. The probable ground water levels monitored during the field work were G.L. -2.10m in BH-1 and G.L. -2.60m in BH-2. It was observed that the water level in the boreholes dropped once the depth of the borehole reached the sandy stratum.

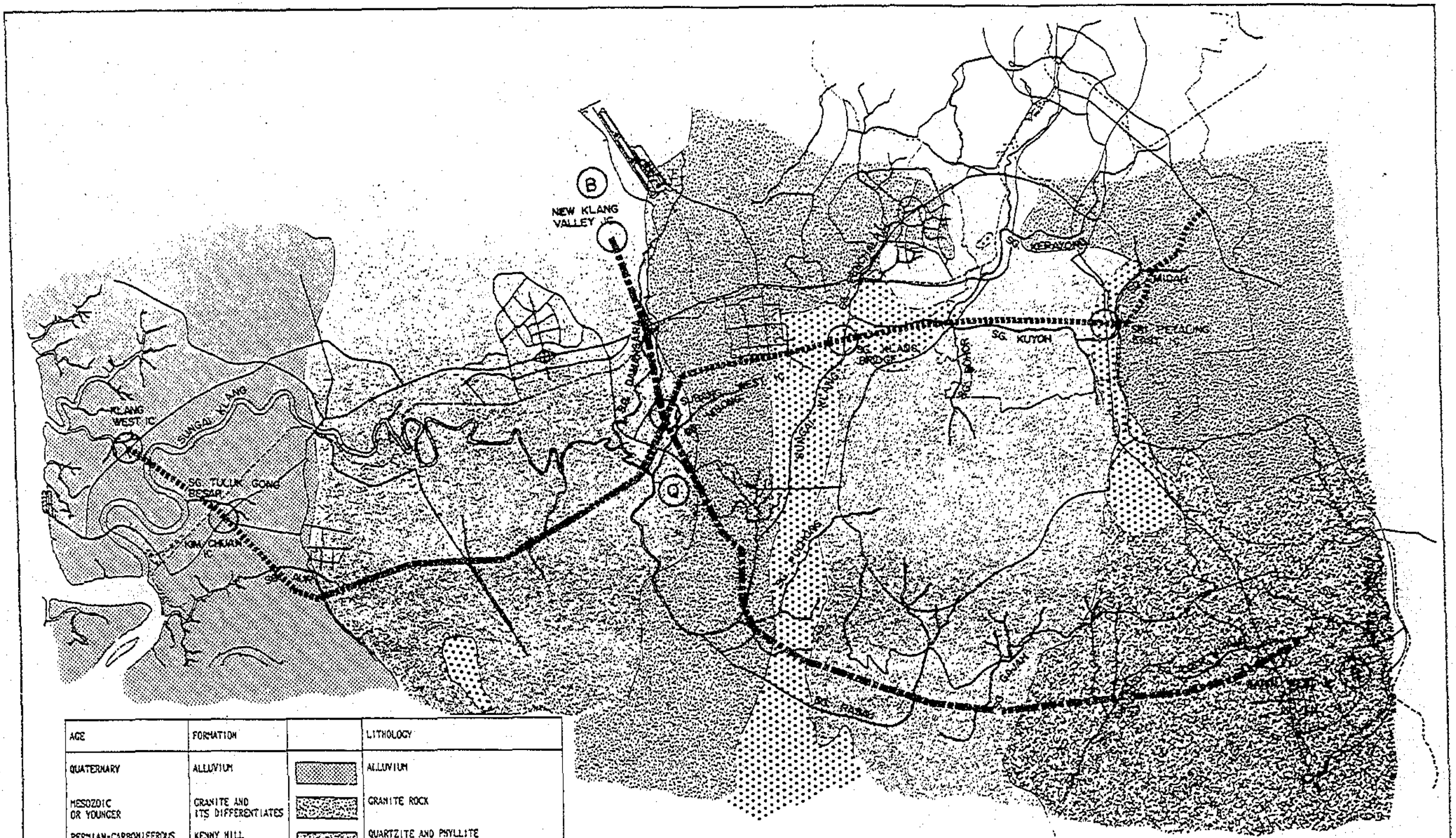
### 5.2.2 Engineering Properties of Construction Materials

(1) General

Three bulks soil samples were collected at three locations for construction materials purpose. The sample collected and their location are as follows:-

| Location | Type of Soil |
|---|---|
| Subang | Laterite Soil |
| Bangi | Kajang Formation Soil |
| Puchong | Tin Mining Sand and Gravel |

The three locations are as shown in Figure 5.2.9. A series of loboratory test were performed on these samples to determine their engineering properties. The results of the loboratory tests are summarized in Tables 5.2.17 and 5.2.18.




| AGE | FORMATION | | LITHOLOGY |
|---|---|---|---|
| QUATERNARY | ALLUVIUM | | ALLUVIUM |
| MESOZOIC OR YOUNGER | GRANITE AND ITS DIFFERENTIATES | | GRANITE ROCK |
| PERMIAN-CARBONIFEROUS PERHAPS TRIASSIC | KENNY HILL FORMATION | | QUARTZITE AND PHYLLITE |
| MIDDLE-UPPER-SILURIAN PERHAPS DEVONIAN | KAJANG FORMATION | | SCHIST WITH MINOR INTERCALATIONS OF LIMESTONE AND PHYLLITE |
| MIDDLE-UPPER SILURIAN | KUALA LUMPUR LIMESTONE | | LIMESTONE WITH MINOR INTERCALATIONS OF PHYLLITE |

Fig 5.2.9: LOCATION OF SOIL SURVEY ON GEOLOGICAL MAP

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

LEGEND:
- SHAH ALAM HIGHWAY
- NORTH SOUTH LINK
- MACHINE BORING
- (Q) MATERIAL TEST FOR QUARRY
- (B) MATERIAL TEST FOR BORROW

SCALE: 0 1 2 3 4 5 km

N

(2) Laterite Soil (Subang)

A laterite soil sample was collected at a road cutting located about 5km north of the New Klang Valley junction site, near to Subang International Airport.

The material collected was the residual soil derived from the sedimentary rock of the Kenny Hill formation as shown in the geological map in Figure 5.3.1. It consists of yellowish red colour sandy clay soil with traces of gravel.

The laboratory soil test result performed on the soil is summarized in Tables 5.2.17 and 5.2.18.

(3) Kajang Formation (Bangi)

The soil sample of the Kajang Formation was collected at a top of a cut hill in Bangi at the location shown in Figure 5.2.9. The site is located in an area underlain by the Kajang Formation as shown in Figure 5.2.9. The soil sample collected was the residual soil derived from the formation. Sample was taken at a depth of 50cm below the ground surface. It consists of reddish brown sandy clay soil with traces of gravel.

The laboratory soil test result performed on the soil sample is summarized in Tables 5.2.17 and 5.2.18.

(4) Tin Mining Sand and Gravel (Puchong)

The sample was collected in Puchong tin mining area which is located about 2km north east of the Klang bridge site as shown in Figure 5.2.9.

The geological map in Figure 5.2.9 shows the site's location at the geological boundary between the Kuala Lumpur Limestone area and Kenny Hill formation. As mentioned in the earlier section, many tin mines are located in the limestone area.

Table 5.2.17 : Summary of the Soil Properties of Construction Material

| | Laterite Soil | Kajang Formation | Tin Mining Sand | Gravel |
|---|---|---|---|---|
| Natural Water Content (%) | 17.5 | 30.1 | - | - |
| Specific Gravity | 2.679 | 2.722 | 2.659 | 2.65 |
| Liquid Limit (%) | 49 | 67 | - | - |
| Plastic Limit (%) | 20 | 33 | - | - |
| Gravel Content (%) | 1 | 1 | 15 | - |
| Sand Content (%) | 52 | 12 | 79 | - |
| Silt Content (%) | 11 | 40 | - | - |
| Clay Content (%) | 36 | 47 | 6 | - |
| * Maximum Dry Dnsity (mg/cu.m) | 1.899 | 1.72 | 1.787 | - |
| * Optimum Moisture Content (%) | 12.7 | 18.7 | 10.0 | - |
| Water Absorption (%) | - | - | - | 0.23% |
| Percentage of Wear (%) by Los Angeles Abrasion Test | - | - | - | 49.6% |

Compaction Test, 92 blows/layer
Modified Proctor, 3 layers x 92 blows/layer

Table 5.2.18 : Summary of the Modified and Design CBR Test Results of the Construction Material

| Sample and Location | Number of Blows | Swelling Ratio | CBR (%) |
|---|---|---|---|
| Laterite Soil (Subang) | 92 | 3.395 | 8 |
| | 42 | 2.82 | 5 |
| | 17 | 2.71 | 2 |
| | 67* | 0.112 - 0.20 | 2 - 4 |
| Kajang Formation (Bangi) | 92 | 2.43 | 14 |
| | 42 | 2.56 | 7 |
| | 17 | 3.02 | 1 (0.5) |
| | 67* | -0.3 - 0.02 | 2 |
| Tin Mining Sand (Puchong) (Puchong) | 92 | -0.40 | 29 |
| | 42 | -0.08 | 25 |
| | 17 | -0.103 | 8 |

* Design CBR at natural moisture content, 3 layers x 67 blows/layers
Energy: 4.5kg rammer x 45 cm height

The sample collected was the residual material from the mining operation which consists of gravel and sand. During the segregation process, tin ore was separated from the residual material such as the gravel, sand, silt and clay. Usually these residual material are dumped in the so called tailing pond.

Sand quarries operated from abandoned tin mines existing around the site.

The laboratory soil test results on the sand and gravel samples are summarized in Tables 5.2.17 and 5.2.18. The laboratory test result performed on the gravel are shown in Table 5.2.19.

Table 5.2.19 : Laboratory Test Result of Tin Mine Gravel

| | |
|---|---|
| Specific Gravity | 2.65 |
| Water Absorption (%) | 0.23% |
| Percentage of Wear (%)<br>(By Los Angeles Abrasion Test) | 49.6% |