UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2010/2011 Academic Session

April/May 2011

EAL 432/4 – Advanced Highway & Transportation Engineering
[Kejuruteraan Lebuhraya dan Pengangkutan Lanjutan]

Duration: 3 hours
Masa : 3 jam

Please check that this examination paper consists of FOURTEEN (14) pages of printed material including Appendix before you begin the examination.
[Sila pastikan bahawa kertas peperiksaan ini mengandungi EMPAT BELAS (14) muka surat yang bercetak termasuk Lampiran sebelum anda memulakan peperiksaan ini.]

Instructions: This paper contains FIVE (5) questions. Answer FOUR (4) questions.
[Arahan : Kertas ini mengandungi LIMA (5) soalan. Jawab EMPAT (4) soalan.]

You may answer the question either in Bahasa Malaysia or English.
[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris].

All questions MUST BE answered on a new page.
[Semua soalan MESTILAH dijawab pada muka surat baru].

In the event of any discrepancies, the English version shall be used.
[Sekiranya terdapat perbezaan pada soalan peperiksaan, versi Bahasa Inggeris akan diguna pakai].
1. The Malaysian Highway Network Development Plan for 2011 requires balanced approach between passenger cars and public transport (bus). To determine the split between them, the Logit model is employed. The necessary information to determine the modal split between Taiping and Pulau Pinang are shown in the following map and tables. The map and distance can be seen in figure 1. Answer the following questions:

(a) Determine the modal split between Taiping and Pulau Pinang. [5 marks]

(b) After implementing service improvements to the buses, the modal split changed to 80.6% cars and 19.4% buses, determine values of estimated parameter $\beta_1$ and $\beta_2$ and discuss in what terms the service are improved after implementation. [5 marks]

(c) If we implement tool fee for car as RM 0.15 for every km, then determine the utility function for car and the modal split between Taiping and Pulau Pinang. [8 marks]

(d) If the Government decides to spend money to create and improve motorcycle trails so that riding becomes a viable option, and motorcycle trip is similar to a bus trip, its trip takes 5 minutes more than a bus trip but with no waiting time, determine the modal split between Taiping and Pulau Pinang. [7 marks]

Figure 1: Taiping - Pulau Pinang route map (Resource: Google maps)
Table 1: Service Parameters

<table>
<thead>
<tr>
<th>Service</th>
<th>Car</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of petrol</td>
<td>RM 2.0/litre</td>
<td>N.A</td>
</tr>
<tr>
<td>Average fuel consumption</td>
<td>15 litre/100 km</td>
<td>N.A</td>
</tr>
<tr>
<td>Fare</td>
<td>N.A</td>
<td>RM 2.80 for 20 km</td>
</tr>
<tr>
<td>Waiting time</td>
<td>N.A</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Travel time</td>
<td>25 minutes</td>
<td>35 minutes</td>
</tr>
<tr>
<td>Parking time</td>
<td>7 minutes</td>
<td>N.A</td>
</tr>
</tbody>
</table>

Table 2: Utility function

<table>
<thead>
<tr>
<th></th>
<th>$b_1$</th>
<th>$b_2$</th>
<th>$b_3$</th>
<th>$b_4$</th>
<th>$b_5$</th>
<th>$b_6$</th>
<th>Out-of-pocket (OOP) (RM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td></td>
<td>1</td>
<td>0</td>
<td>WT (car)</td>
<td>TT (car)</td>
<td>PT (car)</td>
<td>OOP (car)</td>
</tr>
<tr>
<td>Bus</td>
<td>0</td>
<td></td>
<td>1</td>
<td>WT (bus)</td>
<td>TT (bus)</td>
<td>PT (bus)</td>
<td>OOP (bus)</td>
</tr>
</tbody>
</table>

Table 3: Calibrated estimated parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>$b_1$</td>
<td>-0.33</td>
</tr>
<tr>
<td>$b_2$</td>
<td>-0.27</td>
</tr>
<tr>
<td>$b_3$</td>
<td>-0.10</td>
</tr>
<tr>
<td>$b_4$</td>
<td>-0.13</td>
</tr>
<tr>
<td>$b_5$</td>
<td>-0.12</td>
</tr>
<tr>
<td>$b_6$</td>
<td>-0.00045</td>
</tr>
</tbody>
</table>

2. Trip assignment is one of the stages in Travel Demand Forecasting Process. Trip assignment study was conducted at Pulau Pinang. The area of study was divided into five centers (Balik Pulau, Bukit Bendera, Batu Feringgi, Tg. Bunga and USM main campus) which were connected to the highway network as shown in Figure 2. Average speed and distance between centers are shown in Table 4. Trips between centers have been monitored and result is presented in Table 5. Based on the above information:

(a) Show the minimum path using the all-or-nothing assignment technique with the diagram and assign trips for all the centers.  
[5 marks]

(b) Provide a list of links in the network and indicate the total trips assigned to each link.  
[5 marks]

(c) Determine the total vehicle-minutes of travel and discuss briefly on the result obtained.  
[5 marks]

d) If all access from and to Tg. Bunga is closed, then identify the minimum path, assigned trips for the centers and total vehicle-minutes of travel.  
[10 marks]
Table 4: Average speed performance at links

<table>
<thead>
<tr>
<th>Links</th>
<th>Average speed (km/h)</th>
<th>Distance (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balik Pulau - Bukit Bendera</td>
<td>26.7</td>
<td>8.0</td>
</tr>
<tr>
<td>Balik Pulau - USM main campus</td>
<td>60.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Bukit Bendera - Batu Feringgi</td>
<td>75.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Bukit Bendera - Tg. Bunga</td>
<td>54.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Bukit Bendera - USM main campus</td>
<td>21.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Batu Feringgi - Tg. Bunga</td>
<td>24.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Tg. Bunga - USM main campus</td>
<td>75.0</td>
<td>15.0</td>
</tr>
</tbody>
</table>

Table 5: Trips between centers

<table>
<thead>
<tr>
<th>From/To</th>
<th>Balik Pulau</th>
<th>Bukit Bendera</th>
<th>Batu Feringgi</th>
<th>Tg. Bunga</th>
<th>USM main campus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balik Pulau</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>200</td>
<td>150</td>
</tr>
<tr>
<td>Bukit Bendera</td>
<td>400</td>
<td>0</td>
<td>200</td>
<td>100</td>
<td>500</td>
</tr>
<tr>
<td>Batu Feringgi</td>
<td>200</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>Tg. Bunga</td>
<td>250</td>
<td>150</td>
<td>300</td>
<td>0</td>
<td>400</td>
</tr>
<tr>
<td>USM main campus</td>
<td>200</td>
<td>100</td>
<td>50</td>
<td>350</td>
<td>0</td>
</tr>
</tbody>
</table>
3. (a) There are three types of design vehicle in the Jabatan Kerja Raya guide namely; P, SU and WB-50.

(i) Distinguish the significant differences between the three design vehicles. Choose TWO (2) design vehicle characteristics and explain briefly their influence on the highway geometric design.

(ii) Name the type of design vehicle you would choose to design junctions in the following areas:
- Residential area.
- Industrial estate.

(iii) Explain briefly the adverse effects on the road physical features if design vehicle type P is selected to design roads in areas dominated by heavy vehicles.

[7 marks]

(b) The coefficient of friction at the tyre-pavement interface when the pavement is dry is 0.61. When the pavement is wet, the coefficient of friction reduces by 48%. Consider a vehicle travelling at 80 km/hr on a flat two-lane bothways road.

(i) Calculate the stopping sight distance that will be used in the road geometric design assuming a 2.5 s standard reaction time.

(ii) Calculate the required stopping sight distance if the road is sloping downwards at 4.0%?

(iii) Use your engineering judgment and state the stopping sight distance value that would be used in the actual geometric design of a two-lane bothways road and state your reasons.

[6 marks]

(c) From the perspective of a driver, a fully straight road is desirable. Identify FOUR (4) reasons why this concept cannot be implemented in the horizontal design of highways. The Malaysian Highway Authority (LLM) Standards does not recommend the application of a straight longer than 2 minutes of driving at the design speed. If the design speed of a highway is 100 km/h, calculate the permissible maximum length of straight.

[6 marks]

(d) In a horizontal alignment design, a transition curve is introduced between the straight and the circular curve. Discuss briefly FOUR (4) reasons why transition curves are essential.

[6 marks]
4. (a) In a vertical alignment, the straight connect two vertical curves.

   (i) Name TWO (2) criteria that govern the design of the straight in a vertical alignment.

   (ii) Discuss briefly the factors considered in selecting the design value.

   (iii) The topography where a proposed road will traverse dictates provision of a steep, long and continuous straight. As a designer, formulate the steps you will take to increase the road capacity at this section.

   [8 marks]

(b) On a JKR road hierarchy R5, a +2.5% grade intersects a -3.7% grade and the road passes through a rolling topography. Calculate the minimum length of vertical curve required to fulfill the following requirements:

   (i) Stopping sight distance.

   (ii) Drainage.

   (iii) Comfort.

   (iv) JKR guide given in Appendix A.

   Given: Stopping sight distance = 140 m, driver eye height = 0.92 m, obstruction object height = 0.15 m, minimum longitudinal slope for drainage = 0.35%. State all other assumptions used.

   • Appraise the values obtained and justify which value you would adopt for design purposes.

   [12 marks]

(c) The strip of land alongside a highway is described as the right of way. Explain briefly why is this strip of land essential? Briefly explain FOUR (4) factors that govern the width of a road reserve.

   [5 marks]

5. (a) Speed change lanes are additional lanes provided in the vicinity of road intersections.

   (i) With the aid of sketches, indicate the various components in an acceleration and deceleration lanes.

   (ii) Illustrate how do acceleration and deceleration lanes contribute to increase junction capacity.

   [7 marks]

(b) In at-grade-intersection design, two sight distances considered are approach sight distance and departure sight distance. With the aid of sketches, explain these two sight distances. Explain why these sight distances are provided.

   [7 marks]
One of the principles of at-grade junction design is to maintain smooth traffic flow along the major road. Figures 3(a) and 3(b) show a four-legged and three-legged junction, respectively. The approach road carrying heavier traffic volume is indicated by the bold line. Use sketches to re-design the junction configuration to ensure smooth flow of the heavier traffic volume.

Figure 3

Discuss in detail the data needed in the EMME/3 software for the following data categories:

(i) Networks

(ii) Matrices

(iii) Functions

(a) Kira pemisahan ragaman bagi perjalanan antara Taiping dan Pulau Pinang.

[5 markah]

(b) Setelah melaksanakan perbaikan perkhidmatan kepada bas, pemisahan ragaman berubah menjadi 80,6% kereta dan 19,4% bas, kira nilai estimasi parameter \( \beta_1 \) dan \( \beta_2 \) dan bincangkan perkhidmatan apa yang bertambah baik setelah pelaksanaan.

[5 markah]

(c) Jika kita melaksanakan tambang tol untuk kereta sebagai RM 0.15 untuk setiap km, tentukan fungsi utiliti untuk kereta dan pemisahan ragaman antara Taiping dan Pulau Pinang.

[8 markah]

(d) Jika kerajaan memutuskan membelanjakan wang untuk mewujudkan dan memperbaik jalan motosikal sehingga motosikal menjadi pilihan yang layak, dan perjalanan motosikal ini serupa dengan perjalanan bas, perjalanan memakan masa 5 minit lebih dari perjalanan bas tapi tak ada waktu tunggu. Kira pemisahan ragaman bagi perjalanan antara Taiping dan Pulau Pinang.

[7 markah]

Rajah 1: Peta lebuhraya Taiping - Pulau Pinang (Sumber: Google maps)
Jadual 1: Parameter perkhidmatan

<table>
<thead>
<tr>
<th>Perkhidmatan</th>
<th>Kereta</th>
<th>Bas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kos petrol</td>
<td>RM 2.0/liter</td>
<td>N.A</td>
</tr>
<tr>
<td>Purata penggunaan minyak</td>
<td>15 liter/100 km</td>
<td>N.A</td>
</tr>
<tr>
<td>Tambang</td>
<td>N.A</td>
<td>RM 2.80 untuk 20 km</td>
</tr>
<tr>
<td>Masa menunggu</td>
<td>N.A</td>
<td>10 minit</td>
</tr>
<tr>
<td>Masa perjalanan</td>
<td>25 minit</td>
<td>35 minit</td>
</tr>
<tr>
<td>Masa letak kenderaan</td>
<td>7 minit</td>
<td>N.A</td>
</tr>
</tbody>
</table>

Jadual 2: Fungsi kegunaan

<table>
<thead>
<tr>
<th></th>
<th>(\beta_1)</th>
<th>(\beta_2)</th>
<th>(\beta_3)</th>
<th>(\beta_4)</th>
<th>(\beta_5)</th>
<th>(\beta_6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kereta</td>
<td>Indeks pemboleh ubah untuk kereta</td>
<td>Indeks pemboleh ubah untuk bas</td>
<td>Masa menunggu (WT) (minit)</td>
<td>Masa perjalanan (TT) (minit)</td>
<td>Masa letak kenderaan (PT) (minit)</td>
<td>Belanja tunai langsung (OOP) (RM)</td>
</tr>
<tr>
<td>Bas</td>
<td>0</td>
<td>1</td>
<td>WT (kereta)</td>
<td>TT (kereta)</td>
<td>PT (kereta)</td>
<td>OOP (kereta)</td>
</tr>
</tbody>
</table>

Jadual 3: Parameter yang telah ditentukur

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Nilai</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\beta_1)</td>
<td>-0.33</td>
</tr>
<tr>
<td>(\beta_2)</td>
<td>-0.27</td>
</tr>
<tr>
<td>(\beta_3)</td>
<td>-0.10</td>
</tr>
<tr>
<td>(\beta_4)</td>
<td>-0.13</td>
</tr>
<tr>
<td>(\beta_5)</td>
<td>-0.12</td>
</tr>
<tr>
<td>(\beta_6)</td>
<td>-0.00045</td>
</tr>
</tbody>
</table>


(a) Tentukan laluan minimum dengan menggunakan kaedah pengumpukan semua-atau-tiada dengan rajah dan tentukan jumlah perjalanan untuk semua pusat.

[5 markah]

(b) Senarai sambungan setiap rangkaian dan kenalpasti jumlah perjalanan setiap satu.

[5 markah]

(c) Kira jumlah kenderaan-minit dan bincangkan secara ringkas keputusan yang diperoleh.

[5 markah]
(d) Jika semua akses dari dan ke Tg. Bunga tertutup, kenalpasti laluan minimum, umpukan perjalanan untuk semua pusat dan jumlah kenderaan-minit.

[10 markah]

Rajah 2: Peta Pulau Pinang

Jadual 4: Purata prestasi kelajuan pada sambungan

<table>
<thead>
<tr>
<th>Sambungan</th>
<th>Purata kelajuan (km/j)</th>
<th>Jarak (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balik Pulau - Bukit Bendera</td>
<td>26.7</td>
<td>8.0</td>
</tr>
<tr>
<td>Balik Pulau - USM kampus induk</td>
<td>60.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Bukit Bendera - Batu Feringgi</td>
<td>75.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Bukit Bendera - Tg. Bunga</td>
<td>54.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Bukit Bendera - USM kampus induk</td>
<td>21.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Batu Feringgi - Tg. Bunga</td>
<td>24.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Tg. Bunga - USM kampus induk</td>
<td>75.0</td>
<td>15.0</td>
</tr>
</tbody>
</table>

Jadual 5: Perjalanan antara pusat

<table>
<thead>
<tr>
<th>Dari/ke</th>
<th>Balik Pulau</th>
<th>Bukit Bendera</th>
<th>Batu Feringgi</th>
<th>Tg. Bunga</th>
<th>USM kampus induk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balik Pulau</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>200</td>
<td>150</td>
</tr>
<tr>
<td>Bukit Bendera</td>
<td>400</td>
<td>0</td>
<td>200</td>
<td>100</td>
<td>500</td>
</tr>
<tr>
<td>Batu Feringgi</td>
<td>200</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>Tg. Bunga</td>
<td>250</td>
<td>150</td>
<td>300</td>
<td>0</td>
<td>400</td>
</tr>
<tr>
<td>USM kampus induk</td>
<td>200</td>
<td>100</td>
<td>50</td>
<td>350</td>
<td>0</td>
</tr>
</tbody>
</table>
3. (a) Terdapat tiga jenis kenderaan reka bentuk yang dinyatakan di dalam garis panduan Jabatan Kerja Raya iaitu P, SU dan WB-50.

(i) Bezakan di antara ketiga-tiga kenderaan reka bentuk. Pilih DUA (2) ciri kenderaan reka bentuk dan terangkan secara ringkas pengaruhnya ke atas reka bentuk geometri.

(ii) Namakan jenis kenderaan reka bentuk yang akan anda pilih untuk mereka-bentuk persimpangan di kawasan berikut:
   - Kawasan perumahan.
   - Kawasan industri.

(iii) Terangkan secara ringkas kesan buruk ke atas sifat fizikal jalan raya jika kenderaan reka bentuk jenis P dipilih untuk mereka bentuk jalan di kawasan yang menampung kenderaan berat.

[7 markah]

(b) Pekali geseran pada antaramuka tayar-turapan ketika permukaan turapan kering ialah 0.61. Apabila turapan basah, pekali geseran mengurang sebanyak 48%. Pertimbangkan sebuah kenderaan sedang bergerak pada kelajuan 80 km/j di atas jalan datar dua-lorong dua-hala.

(i) Kira jarak penglihatan berhenti yang akan digunakan dalam reka bentuk geometri. Andaikan masa tindakbalas piawai 2.5 saat.

(ii) Kira jarak penglihatan berhenti yang diperlukan jika jalan raya menuruni bukit sebanyak 4.0%.

(iii) Gunakan penilaian kejuruteraan anda untuk menentukan nilai jarak penglihatan berhenti yang akan digunakan di dalam reka bentuk geometri jalan dua-lorong dua-hala dan nyatakan justifikasi anda.

[6 markah]

(c) Daripada perspektif seorang pemandu, jalan yang lurus sepenuhnya dihajatkan. Kenalpasti EMPAT (4) alasan kenapa konsep ini tidak boleh diimplimentasi dalam reka bentuk penjajaran datar lebuh raya? Piawai Lembaga Lebuh Raya Malaysia (LLM) tidak menggalakkan aplikasi jalan lurus yang panjangnya melebihi 2 minit memandu pada laju reka bentuk. Jika laju reka bentuk sebatang lebuh raya ialah 100 km/j, kira panjang maksimum panjang lurus yang dibenarkan.

[6 markah]

(d) Dalam reka bentuk penjajaran datar, lengkung peralihan diperkenalkan di antara jalan lurus dan lengkung bulat. Bincangkan secara ringkas EMPAT (4) alasan kenapa lengkung peralihan diperlukan.

[6 markah]
4. (a) Dalam penjajaran tegak, jalan lurus menghubungi dua lengkung tegak.

(i) Namakan DUA (2) kriteria yang mengawal reka bentuk jalan lurus di dalam penjajaran tegak.

(ii) Bincangkan secara ringkas faktor yang dipertimbangkan dalam pemilihan nilai reka bentuk.

(iii) Topografi yang bakal dilalui oleh lebih raya memaksakan aplikasi jalan lurus yang curam, panjang dan berterusan. Selaku pereka bentuk, rumuskan langkah yang akan anda lakukan untuk meningkatkan muatan lebih raya pada seksyen ini.

[8 markah]

(b) Sebatang jalan JKR berhirarki R5 merentasi topografi beralun. Gred +2.5% memintas gred -3.7%. Kira panjang lengkung minimum yang diperlukan untuk memenuhi keperluan berikut:

(i) Jarak penglihatan berhenti.

(ii) Penyaliran.

(iii) Keselesaan.

(iv) Garispanduan JKR yang diberikan di dalam Lampiran A.

Di beri: Jarak penglihatan berhenti = 140 m, ketinggian mata pemandu = 0.92 m, ketinggian objek gangguan = 0.15 m, cerun membujur minimum untuk penyaliran = 0.35%. Nyatakan semua andaian lain yang digunakan.

- Komen nilai yang diperolehi dan berikan justifikasi nilai yang akan anda gunakan di dalam reka bentuk.

[12 markah]

(c) Sejalur tanah yang terletak bersebelahan dengan lebih raya dinamai hak lalu. Terangkan secara ringkas kenapakah hak lalu diperlukan? Bincangkan secara ringkas EMPAT (4) faktor yang mempengaruhi lebar hak lalu.

[5 markah]

5. (a) Lorong tukar laju merupakan lorong tambahan yang disediakan di kawasan persimpangan.

(i) Berbantukan lakaran, tunjukkan komponen yang terdapat di dalam lorong pecutan dan lorong nyahpecutan.

(ii) Bagaimanakah lorong pecutan dan nyahpecutan membantu meningkatkan muatan persimpangan?

[7 markah]
(b) Dalam reka bentuk persimpangan searas, dua jenis jarak penglihatan yang dipertimbangkan ialah jarak penglihatan menuju dan jarak penglihatan berlepas. Berbantukan lakaran, terangkan dua jenis jarak penglihatan ini. Kenapa jarak penglihatan ini perlu disediakan?

[7 markah]

(c) Satu daripada prinsip reka bentuk persimpangan searas ialah untuk mengekalkan kelancaran pergerakan lalu lintas di atas jalan utama. Rajah 3 (a) dan 3 (b) masing-masing menunjukkan simpang empat dan simpang tiga. Jalan tuju yang menampung isi padu lalu lintas yang lebih tinggi dilakarkan oleh garisan tebal. Gunakan lakaran untuk menunjukkan bagaimanakah cara untuk merekabentuk semula konfigurasi persimpangan ini supaya keterusan isipadu lalu lintas yang tinggi dapat dikekalkan.

[5 markah]

Rajah 3

(d) Terangkan secara terperinci data yang diperlukan dalam perisian EMME/3 untuk kategori-kategori data di bawah:

(i) Jaringan

[2 markah]

(ii) Matriks

[2 markah]

(iii) Fungsi

[2 markah]
## Appendix A

### Lampiran A

<table>
<thead>
<tr>
<th>Element</th>
<th>R6 Penuh</th>
<th>R5 Separa</th>
<th>R4 Separa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D  G  B</td>
<td>D  G  B</td>
<td>D  G  B</td>
</tr>
<tr>
<td>Harga jalan</td>
<td>120 100 80</td>
<td>100 80 60</td>
<td>80 60 50</td>
</tr>
<tr>
<td>Kualitas masuk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>laju rekabentuk (km/h)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jarak penghitung berhenti</td>
<td>285 205 140</td>
<td>205 140 85</td>
<td>140 85 65</td>
</tr>
<tr>
<td>Jarak penghitung memotong</td>
<td>N/A</td>
<td>700 550 450</td>
<td>550 450 350</td>
</tr>
<tr>
<td>Jejari minimum</td>
<td>570 375 230</td>
<td>375 230 125</td>
<td>230 125 85</td>
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<tr>
<td>Panjang minimum</td>
<td>133 121 104</td>
<td>88 70 59</td>
<td>70 59 55</td>
</tr>
<tr>
<td>Lengkung puncak (K)</td>
<td>120 60 30</td>
<td>60 30 15</td>
<td>30 15 10</td>
</tr>
<tr>
<td>Lengkung lendut (K)</td>
<td>60 40 28</td>
<td>40 28 15</td>
<td>28 15 12</td>
</tr>
</tbody>
</table>

**Catatan:**
- D = Rupa bumi datar
- G = Rupa bumi giling
- B = Rupa bumi berbukit
- N/A = Tidak berlaku
- (1) = Lebar keseluruhan turapan
- (2) = Lebar hak lalu bergantung pada hirarki jalan

-ooooO000oo-