THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING – 3rd YEAR DEGREE

FIRST SEMESTER EXAMINATION - 2023

CE 313 – Road and Pavement Engineering

DATE: TUESDAY, 6th JUNE 2023 – 12:50 P.M

VENUE: STRUCTURES LECTURE THEATRE (SLT)

TIME ALLOWED: 2 HOURS

INFORMATION FOR CANDIDATES

1. You have 10 minutes to read the paper before the examination starts. You must **not** begin writing during this time.
2. **There are FIVE (5) Questions in this paper. Answer any 4 Questions.**
3. Use only ink. Do not use pencils for writing except for drawings and sketches.
4. Only Calculator is allowed in the examination room. MOBILE PHONE is not allowed (**Switch your Mobile Phones OFF**). Notes and textbooks are not allowed.
5. Start each question on a new page and show all your calculations in the answer book provided. No other material will be accepted.
6. **Write your NAME and Student Id NUMBER clearly on the front page. Do it now.**
7. **Marking Scheme:** All Questions carry equal marks.

QUESTION 1 [10 marks] SLO 1

a) Calculate the design traffic loading as number of ESAs to be used in empirical method of design of unbound granular pavement with thin bituminous surfacing considering rutting and loss of surface shape with the following data:

Design period	P = 20 years
Annual average daily traffic (AADT)	5400
Direction factor	0.5
Percentage of heavy vehicle	4%
Lane distribution factor	1.0

Heavy vehicle growth rate (compound), R = 4%

Assume sum of the single axle single tyre (SAST) and tandem axle single tyre (TAST) is 0.4 and the sum of the weighted ESA values as 0.8. Assume any other data if needed.

Cumulative growth factor (CGF) = $[(1+ 0.01R)^P - 1]/(0.01R)$ for R>0

= P for R = 0 (8 marks)

b) Write the full form of "DESA" (2 marks)

QUESTION 2 [10 marks]

[Answer any 5 questions 2 x 5=10 marks] SLO 2

a) Which more direct and fundamental approach avoids the need to convert different axle configurations to an equivalent load such as an ESA in aircraft traffic loading? (2 marks)

b) Define ESWL in the context of aircraft traffic loading. (2 marks)

c) Based on which parameter standard charts relating subgrade CBR and pavement thickness are available? (2 marks)

d) Fill in the blank:
Several wheel gear loads are converted to _____. (2 marks)

e) Fill in the blank:
ESWLs of different aircrafts are converted to those of _____ (2 marks)

f) Which program is developed by Australians for aerodrome pavement design? (2 marks)

g) FAA's FAARFIELD has now replaced by which program? (2 marks)

OR [10 marks] SLO 2

a) Differentiate among the runway, taxiway and Apron with simple sketches. (.6 marks)

b) Draw structures of aerodrome pavements side by side showing typical layers. (4 marks)

QUESTION 3 [10 marks] SLO 3

a) Design a flexible pavement utilizing various qualities of granular materials based on the following design parameters:
sprayed bituminous seal surface
subgrade design CBR = 3%
design traffic = 6 × 10^6 ESA.
There are three granular materials available for use:
crushed rock base (CBR ≥ 80%)
crushed rock upper subbase(CBR ≥ 30%)
gravel lower subbase(CBR ≥ 15%)
Use empirical method (6 marks)

b) What typical behavior is exhibited by rigid pavement layer over the sub grade layer? (2 marks)

c) Differentiate between the rigid and flexible pavements. (2 marks)

QUESTION 4 [10 marks] [Answer any 5 questions 2 x 5=10 marks] SLO 4 & 5

a) What is the effect of water on road materials and pavements? (2 marks)

b) Write on an effective methodology for prevention of potholes (2 marks)

c) Define CBR value of subgrade. (2 marks)

d) What is the difference between "fatigue-cracking " and "rutting damage" criteria? (2 marks)

e) What do you understand by the term Geotextile? Classify geotextiles. (2 marks)

f) What is meant by bituminous materials? Classify bituminous materials. (2 marks)

g) What is the difference between the 60/70 and 80/100 bitumen? (2 marks)

QUESTION 5 [10 marks] SLO 6

a) A road embankment is 10m wide with side slopes 2:1. Assuming the ground to be level in a direction transverse to the centre line, calculate the volume contained in a length of 150 metres, the central heights at 30m intervals being 2.5, 3.00, 3.5, 4.0, 3.75 and 2.75m respectively. Use prismoidal formula. (4 marks)

b) Calculate the minimum radius of curvature for a horizontal curve in a road alignment designed for a speed of 100 kmph. Given the permissible value of super elevation is 0.08 and coefficient of friction is 0.12. (4 marks)

c) Write short note on PIEV theory. (2 marks)

Table I 1: Project traffic load distribution

Axle group load (kN)	Axle group type				
	SAST %	SADT %	TAST %	TADT %	TRDT %
10	0.2569	2.1721	0.1033	0.0971	0.0043
20	13.5274	19.2319	0.9555	0.6798	0.1057
30	18.0187	20.6747	1.2562	1.4085	0.2529
40	19.9923	17.9923	1.3315	3.7622	1.3424
50	25.7879	13.4201	4.5162	7.7252	4.9203
60	17.1140	8.2995	13.6576	10.3152	9.4372
70	4.3703	6.2664	17.8501	10.2244	9.7940
80	0.7690	7.6773	17.3598	8.5571	8.5152
90	0.1132	6.3741	13.2328	6.7696	6.5257
100	0.0573	3.5762	9.9221	5.3412	4.3467
110	0.0128	1.6888	9.7695	4.3509	3.1213
120	0.0128	0.9164	4.6585	4.1451	2.7006
130	0.0038	0.4354	2.3255	4.2917	2.4734
140	0.0053	0.1888	1.1946	4.7138	2.6452
150		0.0456	0.8719	6.1501	3.0875
160		0.0250	0.3259	5.7139	3.4186
170		0.0000	0.3109	4.9741	3.5056
180		0.0079	0.1289	3.3297	4.2435
190		0.0000	0.1025	2.6397	6.2365
200			0.0275	1.7043	7.2186
210				1.1941	5.2376
220				0.5293	3.7047
230				0.4222	2.0195
240				0.2111	1.4500
250				0.1620	0.5963
260				0.0753	0.6025
270				0.0752	0.6229
280				0.0137	0.3055
290				0.0094	0.1953
300				0.0000	0.1616
310				0.0110	0.0409
320				0.0045	0.0257
330				0.0000	0.0254
340				0.0045	0.0181
350					
Proportion of each axle group	0.3799	0.2171	0.0216	0.2591	0.1223

Table I 4: ESA for each axle group load of each axle group type

Axle group load (kN)	Axle group type				
	SAST	SADT	TAST	TADT	TRDT
10	0.000	0.000	0.000	0.000	0.000
20	0.001	0.000	0.000	0.000	0.000
30	0.007	0.001	0.000	0.000	0.000
40	0.025	0.002	0.000	0.000	0.000
50	0.077	0.004	0.000	0.000	0.000
60	0.107	0.006	0.001	0.001	0.000
70	0.051	0.005	0.001	0.002	0.000
80	0.015	0.017	0.002	0.003	0.000
90	0.004	0.022	0.003	0.003	0.000
100	0.003	0.019	0.003	0.004	0.000
110	0.001	0.013	0.005	0.005	0.001
120	0.001	0.010	0.003	0.007	0.001
130	0.001	0.007	0.002	0.010	0.001
140	0.001	0.004	0.002	0.014	0.001
150	0.000	0.001	0.002	0.024	0.002
160	0.000	0.001	0.001	0.029	0.002
170	0.000	0.000	0.001	0.032	0.004
180	0.000	0.000	0.000	0.028	0.006
190	0.000	0.000	0.000	0.027	0.009
200	0.000	0.000	0.000	0.021	0.013
210	0.000	0.000	0.000	0.018	0.011
220	0.000	0.000	0.000	0.015	0.010
230	0.000	0.000	0.000	0.009	0.008
240	0.000	0.000	0.000	0.006	0.005
250	0.000	0.000	0.000	0.005	0.004
260	0.000	0.000	0.000	0.003	0.003
270	0.000	0.000	0.000	0.003	0.004
280	0.000	0.000	0.000	0.001	0.002
290	0.000	0.000	0.000	0.001	0.002
300	0.000	0.000	0.000	0.000	0.001
310	0.000	0.000	0.000	0.001	0.000
320	0.000	0.000	0.000	0.000	0.000
330	0.000	0.000	0.000	0.000	0.000
340	0.000	0.000	0.000	0.000	0.000
350	0.000	0.000	0.000	0.000	0.000
				Average ESA/HVAG	0.80

Figure 8.4: Design chart for granular pavements with thin bituminous surfacing