GX493

OLLSCOIL na hÉIREANN, GAILLIMH

*NATIONAL UNIVERSITY OF IRELAND, GALWAY*

# FIRST SEMESTER EXAMINATIONS, 2000

## B.E. DEGREE

Civil Engineering and Environmental Engineering
(CE 418)
HIGHWAY AND TRAFFIC ENGINEERING II

Professor R. Falconer;
Professor P. E. O'Donoghue;
Dr. M. J. Brennan;
F. Gilmore.

Time allowed: two hours.
Answer all questions.

1. (30%) You are provided with the following files on the server:

| | |
|---|---|
| **Drawing File:** | Exam.dwg |
| **Digital Terrain Model:** | Exam.dtm |

The details for the four Intersection Points (IP) of the three tangent lines for the horizontal alignment of a highway are:

| Point | Easting and Northing | | Curve Radius |
|---|---|---|---|
| IP1 | 177314.584 E | 226471.590 N | – |
| IP2 | to be determined from Exam.dwg | | Radius = 725 m |
| IP3 | to be determined from Exam.dwg | | Radius = 700 m |
| IP4 | 178533.313 E | 227695.043 N | – |

The start chainage at IP1 is 1000 m. Simple horizontal curves and the default values for the stake interval, transition lengths and superelevation are required. On the curves, the pavement should be rotated about the inner edge.

The Intersection Points for the gradients on the vertical alignment are:

| Point | Chainage | Level | Curve length |
|---|---|---|---|
| IP1 | 1000 m | 82.48 | – |
| IP2 | 1420 m | 82.36 | 300 m |
| IP3 | 2160 m | 85.43 | 300 m |
| IP4 | 2580 m | 81.27 | 400 m |
| IP5 | 2800 m | 78.35 | – |

Input the design data to DOER design program, creating a file called **Exam.a01**, and produce the following output <u>noting your name and examination number</u>:

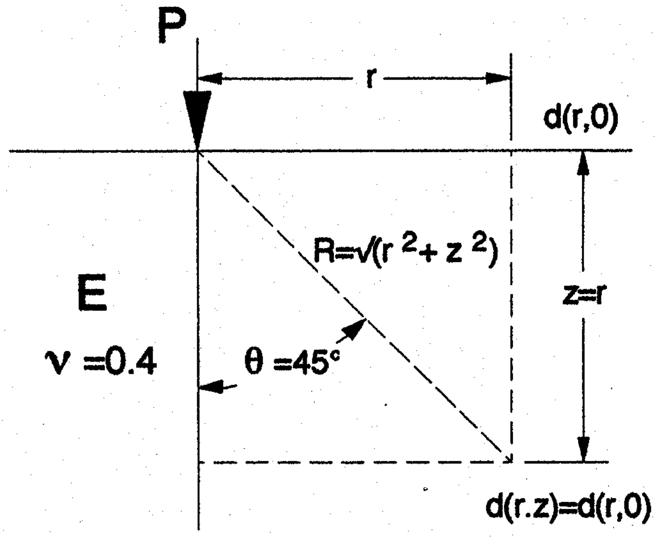
Printout of the Horizontal Curve Elements
Printout of the Horizontal Data for chainage 1580 m
Printout of the Vertical Curve Elements
Printout of the Vertical Data for chainage 1460 m
Plot of the cross-section at chainage 1460 m

**2.** **(a)** (20%) Given that the vertical deflection d(r,z) under a point load, P, at a point with polar co-ordinates (R,θ) is given by the Boussinesq equation:

$$d(r,z) = \frac{(1+\nu)P}{2\pi RE}\left\{2(1-\nu)+Cos^2\theta\right\}$$

Show that the deformation above the 45° zone of influence is practically zero in a one-layer elastic pavement with a Young's modulus, E, and Poisson's ratio, ν, equal to 0.4, by proving that

$$d(r,0) \approx d(r,z)$$



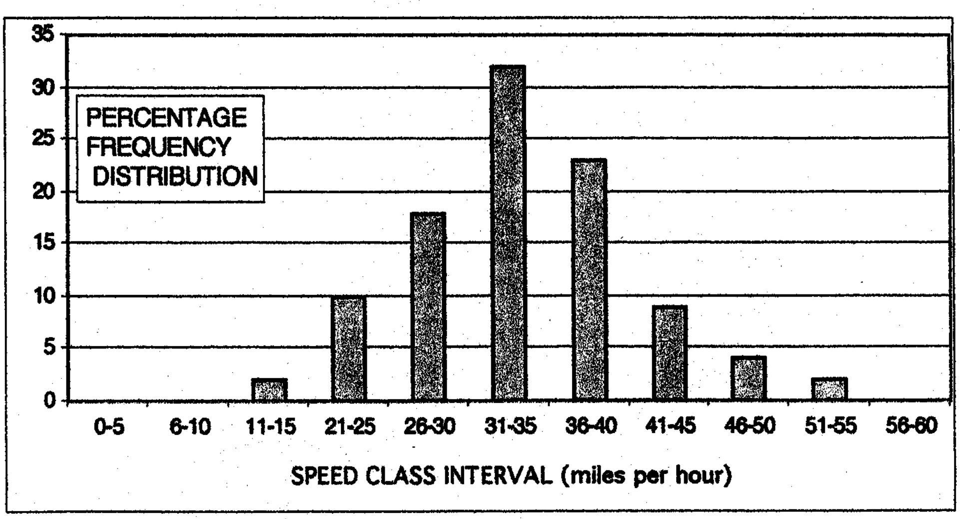

**(b)** (10%) The magnitude of the load obtained using a Falling Weight Deflectometer is 40.5 kN. The radius of the contact plate is 150 mm. Using the above equation, estimate the stiffness (MPa) of a subgrade soil from the following deflection basin data and, hence, indicate its California Bearaing Ratio (CBR) range (<10%, 10-20%, 20-30%. >30%):

DEFLECTIONS IN MICRONS AT 300 mm INCREMENTS

| (Centre) | 300 mm | 600 mm | 900 mm | 1200 mm | 1500 mm | 1800 mm |
|---|---|---|---|---|---|---|
| 409 μm | 257 μm | 139 μm | 92 μm | 63 μm | 48 μm | 40 μm |

**3.** **(a)** (5%) What are the two criteria that are used to establish a speed limit?

**(b)** (5%) What would be the appropriate speed limit for the percentage speed distribution shown below?



**4.** **(a)** (20%) For a queuing system, the average delay time, $E(v)$, is the sum of the average queuing time, $E(\omega)$,and the average service time, $E(s)$:

$$E(v) = E(\omega) + E(s)$$

Given that the average number in a one-channel queuing system with random arrivals and departures, $E(n)$, is given by

$$E(n) = \frac{\lambda}{\mu - \lambda}$$

where $\lambda$ is the average arrival rate and $\mu$ is the average departure rate, show that the average number in the queue, $E(m)$, is given by:

$$E(m) = \frac{\lambda^2}{\mu(\mu - \lambda)}.$$

{Note that $E(n) = \lambda E(v)$}

**(b)** (10%) At a passport control booth, people arrive at random at a rate of 300 persons per hour. The service time to examine a passport is exponentially distributed with a mean of 9s.

Determine:

the average queueing time, $E(\omega)$,

and

the average queue length given that somebody is waiting to be served:

$$E(m / m > 0) = \frac{\mu}{(\mu - \lambda)}.$$