Highway Engineering A- Report

Design of a new road and car park

BEng – Civil Engineering

School of the Built Environment & Architecture

London South Bank University

Module Tutor: Mr Amer Ali

11/12/2018

Table of Contents

1.0 Introduction:

This report is about the design of a car park for a multi storey office building and the design of a road access the construction site in the bordered area, from point A which is a road to point B which is an office building. When building a road, development system is steadily enhanced by the study of road traffic, stone thickness street alignment and slope inclinations, creating and utilizing stones that are laid in any ordinary, conservative structure, and covered with littler stones to deliver a strong layer. Current streets will in general be built utilizing asphalt as well as concrete.

The road configuration must meet DMRB plan standard and the MFS/structure rules for Leeds city council region enactment to accomplish a road structure that is sustainable, natural benevolent, meets plan requirements and supreme safe.
A minor industrial road is to be designed connecting the junction (point A) to the building (point B)

The plan for the road that is exploring from point A to point B where the passageway of the car park must incorporate a turning heat to vehicular defining moment. The explicit road structure and parts must be sustainable, keeping in mind the suitable plan charts and table to legitimize why explicit the plan was chosen.

2.0 Aim & Objectives

Aim:

The key aim of this report is to propose the construction a road that stretches from Point A in the site map, to the destination marked B. In addition to this, the other key aim of this report is to design a car park for the office-bordered structure.

Objectives:

Individual objectives were to;

1. Propose the new roads design
2. Create drawings with vertical and horizontal alignments
3. Design a car park within the office area with the capability of housing 18 vehicles.
4. Design a junction and a turning head for vehicles.

5. Make sure that the new road designed sits where there are no obstacles blocking its route.
6. Design the layout of pavements
7. Take health & safety, environmental, and sustainability variables into factor at all times

3.0 Geometrical Design & Road Type

3.1 Traffic Flow

The total traffic flow for the new road to be constructed is derived from the coursework brief and is listed below.

- Total traffic (v/d) = 3000
- Total commercial vehicles per day (cv/d) = 160
- Total OGV2 vehicles per day = 40
- Total OGV1+PSV vehicles per day = 160 – 40 = 120

The actual percentage of OGV2 vehicles = $\frac{40}{160} * 100 = 25\%$

Therefore, the percentage of OGV2 vehicles that will be using the new road is 25 % of commercial vehicles per day.

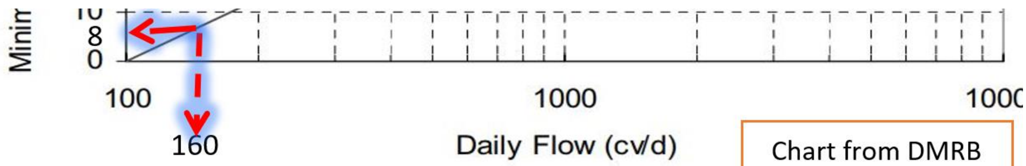


Chart from DMRB

The chart above implies that the minimum percentage of OGV2 for a daily flow of 160 cv/d should be 8%.

Consequently, the previously calculated value (25%) would be used, as the highest OGV2 is always taken.

Figure 1 – Minimum percentage of OGV2 vehicles (%)

3.2 Annual Average Daily Flow – AADT

Carriageway Standard	Opening Year AADT	
	Minimum	Maximum
S2	Up to 13,000	

The road is a single carriageway and will therefore have an AADT flow of up to 13,000 vehicles.

Figure 2 AADT

3.3 Design Traffic – Million standards axles (MSA)

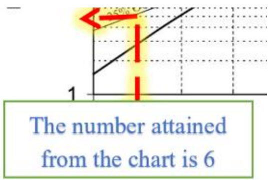


Figure 3 Design traffic vs Daily Flow

3.4 Design Traffic (MSA) – Calculations

Weighted annual traffic

The weighted annual traffic formula is provided using the following formula;

$$\text{Weighted annual traffic} = 365 \times F \times G \times W \times 10^{-6}$$

Where, F is the Flow of traffic

G is the growth factor,

W is the wear factor

10^{-6} is to convert the answer it into msa

The weighted annual traffic for OGV1 + PSV is listed below;

$$Weighted\ annual\ traffic = 365 \times 120 \times 1.19 \times 1.0 \times 10^{-6} = 0.0521\ msa$$

The total weighted annual traffic for OGV2 is derived below;

$$Weighted\ annual\ traffic = 365 \times 40 \times 1.67 \times 4.4 \times 10^{-6} = 0.1073\ msa$$

The total weighted annual traffic is calculated below;

$$Total\ Weighted\ annual\ traffic = 0.1073 + 0.0521 = 0.1594\ msa$$

Design traffic

The design traffic is determined using the following formula;

$$\text{Design Traffic (T)} = Total\ Annual\ Weight\ Traffic \times Y \times P$$

Where, Y is the design period in years

P is the percentage of vehicles in the heaviest traffic lane

The final design traffic is projected below;

$$\text{Total design traffic } = 0.1594 \text{ msa} \times 40 \text{ years} \times 1 = 6.376 \text{ msa}$$

$$\therefore \text{Design Traffic (T)} = 6.376 \approx 6.4 \text{ msa}$$

Consequently, the design traffic calculated before 6 msa is not justifiable to be utilised as its lower than the 6.4 msa.

3.5 Design speed

The design speed of the road is attained by using a speed limit which is specific to the type of road. Safety factors can be added for improvements to the safety of the road.

Specified by the Council of Leeds City, the design speed is 25mph which is equal to 40kph as shown below. This speed limit will be used for the road. The road will be designed around the design speed being the maximum speed to enforce safety while using the road.

Industrial Roads	
i) design speed	25mph
ii) carriageway width	Minimum of 7.3m (unless no HGV's likely) with widening possibly needed on bends or elsewhere (see Section 3.10) or to accommodate right turning at junctions
iii) footway width	2m minimum (on each side of road) or 3m minimum if shared by cyclists
iv) maximum length between speed restraint features	120m (see Section "Speed Restraint")
v) minimum forward visibilities	33m absolute minimum (see para 3.47)
vi) minimum centreline radius	35m (see also Section 'Servicing, Vehicle Tracking and Turning Spaces')

Figure 4 – Industrial Roads

3.6 Stopping Sight Distance (SSD)

$$\text{SSD (m)} = (V \times t) + \frac{V^2}{2d}$$

V: Design speed (m/s) = $\frac{40kph \times 1000}{60 \times 60} = 11.11 m/s$

t: Perception - reaction time (s) is 1.5s – any design speed of less than 50kph will have a value of t as 1.5s

d: Deceleration (m/s^2) = $4.41 m/s^2$

$$(11.11\text{m/s} \times 1.5\text{s}) + \frac{11.11^2}{2 \times 4.41} = 30.67m$$

2 m added to the SSD for car bonnet

30.67m + 2m = 32.67 m = 33 m

3.7 Full Overtaking Sight Distance (FOSD)

FOSD (m) = $2.05 \times t \times v$

T is time (seconds)

V is the design speed (kph)

FOSD (m) = $2.05 \times 10 \times \left(\frac{40\times10^3}{60\times60}\right) = 227.8m$

FOSD (m) = 227.8m $\approx$ 240m

3.8 Super elevation (S %)

S% = $\frac{V^2}{2.828 \times R} = \frac{40^2}{2.828 \times 87} = 6.5\%$

V : Design speed (kpm)
R: Radius of curve (m)

In respect to the Standards for highway superelevation (%) of a road in a rural area must not exceed 7% and the S% is meeting the requirement.

4.0 Horizontal alignment

4.1 Length of curve

The formula to derive the length of the curve for the horizontal curve;

$$L = \frac{V^3}{46.7 \times q \times R}$$

Where, V is the design speed

q is the rate of increase of acceleration along the curve at a steady speed

R is the radius of the curve

Therefore, length of curve = $\frac{40^3}{46.7\times0.3\times87} = 52.5$m

5.0 Vertical alignment

According to Leeds City Council, the ‘desirable maximum vertical gradient is 5%’. The smallest gradient obtained from our graph was 1.153%, whereas the highest gradient was 4.741%. As a result, the design is acceptable to be employed. With a design speed of 25mph (40kph), a minimum k value of 6.5 can be used as shown in the table below.

Street Type	Design Speed (mph)	Minimum K Value	Minimum Curve Length
Type 1	25	6.5	30 m
Type 2	20	3	20 m
Type 3	15	2	20 m
Type 4	10	1	15m

K value obtained = 6.5

Figure 5 Vertical length of curve

(Leeds Government. 2018,p.36)

5.1 Length of curve

The procedure to derive the length of the curve in the vertical alignment is provided below;

$L = KA$

Where, K is derived from table

A is the difference in gradients

A = G1 - G2 = 4.741% - 1.153% = 3.588%

K = 6.5

Length of curve $= 6.5 \times 3.588 = 23.322$m

$\therefore$ Take length of curve as the minimum (30m)

6.0 Car Park Design

Dimension	Length (m)
Parking Bay Width	**2.4 m**
Parking Bay Length	**4.8 m**
Disabled Bay Extension	**1.2 m (both width & length)**

Figure 6 – Parking Dimensions

(Leeds Government. 2018, p.50)

The table above is the dimension for a single car park bay. Furthermore, the full car park consisting of 18 bays (16 normal and 2 disabled) has been sketched using AutoCAD civil 3D.

Car parks need to meet the following requirements when being designed.

- Car park must be structurally safe, practical, and reliable
- Needs to bear in mind the well-being of the people and the safety of the nearby structures
- Car park must be user friendly to accompany vulnerable people like the elderly, disabled etc.
- Must be made of decent design and have regular maintenance.
- Must be aesthetically appeasing in order to upscale the nearby urban environment

(Birmingham City Council. 2018, p.*5)*

7.0 Route Management

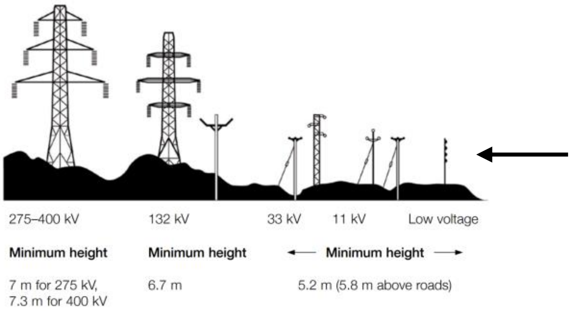
There are number of obstacles that are obscuring the road traffic route. These include but are not limited to the following;

- 400 kilovolt (KV) electricity power line
- Roof containing asbestos
- Site of special scientific interest
- Settled woodlands
- Listed housing buildings

7.1 400KV electricity power line

In the path of the proposed road, a 400KV line runs across the road. Health and safety is a major aspect in the design of any road and since the power lines carry deadly voltages, there has to be a minimum overhead clearance in place.

The figure below illustrates an example of a 400KV line (HSE. 2018, p.4)



As shown in this diagram the 400KV line requires at least a 7.3m clearance from the ground.

Figure 7 – Power line Clearance (HSE. 2018)

7.2 Asbestos roof

Additional aspect of the road management would be the roof that contains the asbestos. Asbestos is a harmful material to human health and it is well documented to cause various diseases including cancer. Therefore, in this case the building that contains the asbestos roof needs to be avoided as part of the route.

7.3 Site of specific scientific interest

Part of the map contains site of specific scientific interest (Sites of Special Scientific Interest | Scottish Natural Heritage. 2018). These are parts of lands that can't be touched because they preserve the environmental heritage of our ecosystem due to them containing either of the following;

- Important geological features
- Conserved plants
- Preserved animals
- Important landforms

This means that it is a crime to cause damage to the elements of SSSI. As a result, the proposed road has to avoid the SSSI area.

7.4 Settled woodlands

The settled woodlands are places that consist of trees and other plants. They are privately owned and cannot be destroyed. Furthermore, the trees have an effect on the visibility of the road user. The proposed road takes this in to consideration.

7.5 Listed building

Part of the road includes listed building that appears to belong to homeowner Amer Ali. This is an inhabited dwelling and cannot be destroyed; hence, the proposed road considers this as part of its design.

8.0 Structural Design

8.1 Pavement Design

Design traffic is 6.4 msa

Foundation class is 2

Material used is HRA 50

CBR% = 6.5% (Group D)

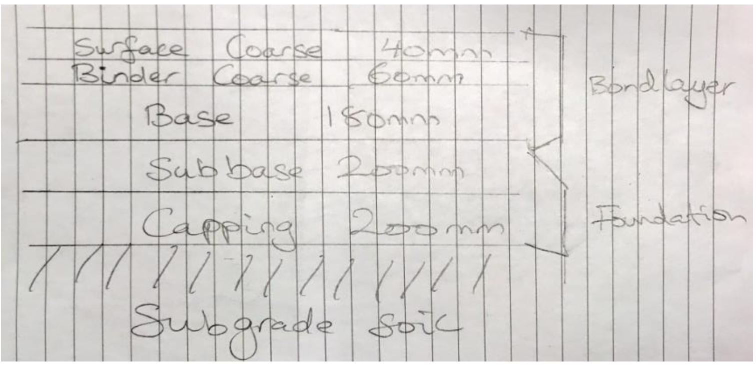
As result the thickness obtained is 280mm

Top surfacing = 100mm (40mm coarse) + (60mm binder)

Base = 280mm – 100mm = 180mm

Sub base thickness = 200mm (derived from CBR%)

Capping thickness = 200mm (derived from CBR%)



This is the pavement design in layers

9.0 Discussion & Analysis

The design of the road was difficult as there were obstacles and cutting down trees and demolishing a building would increase the cost of the project. To ensure the cost to stay as low as possible the obstacles were avoided with radius of 87m. The car parking design required 18 bays. There is a minimum requirement of 10% of the car parking to have disabled parking. Two disabled parking bays were added and made sure it is easier to access the office. The stopping sight distance requires a 2m addition for the calculation because of the car bonnet this increases the SSD value. The CRB % has a direct relation with the sub base and the capping thickness. The lower the CBR% the thicker the sub base and capping layer.

10.0 Conclusion

In conclusion, the goal of this report was to design a road and a car park using the factors given. They were designed using different councils' standard procedure. As this was a minor industrial road, the traffic flow was not significant. However, there were various obstacles hindering the route, which was briefly described in the route management section. All in all, this report was design using whilst taking into consideration the environmental, health & safety, and sustainability factor.

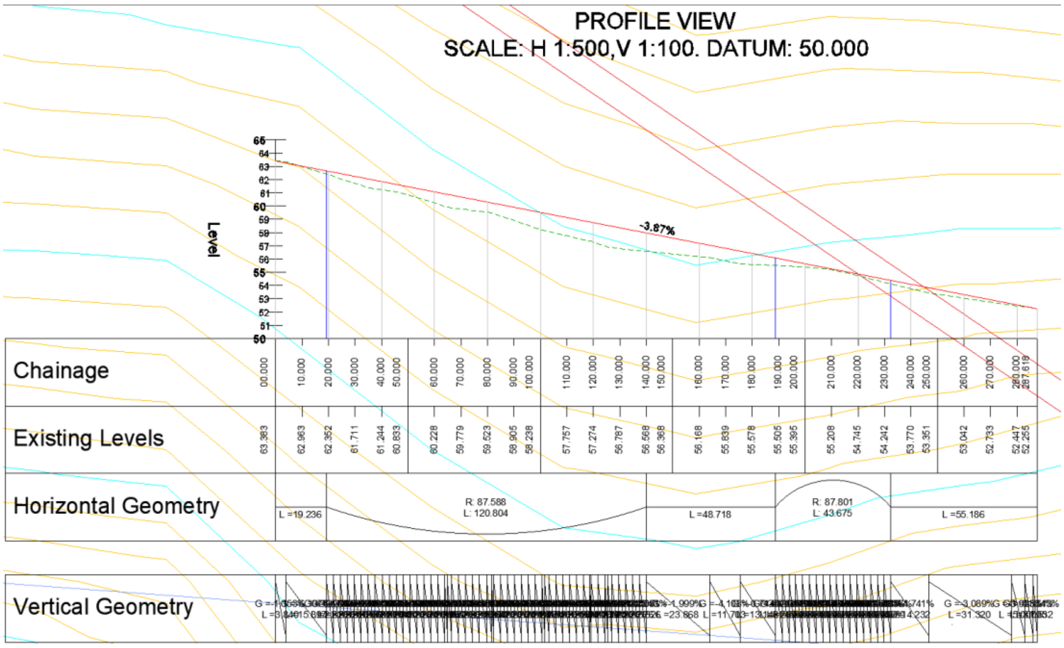
11.0 References

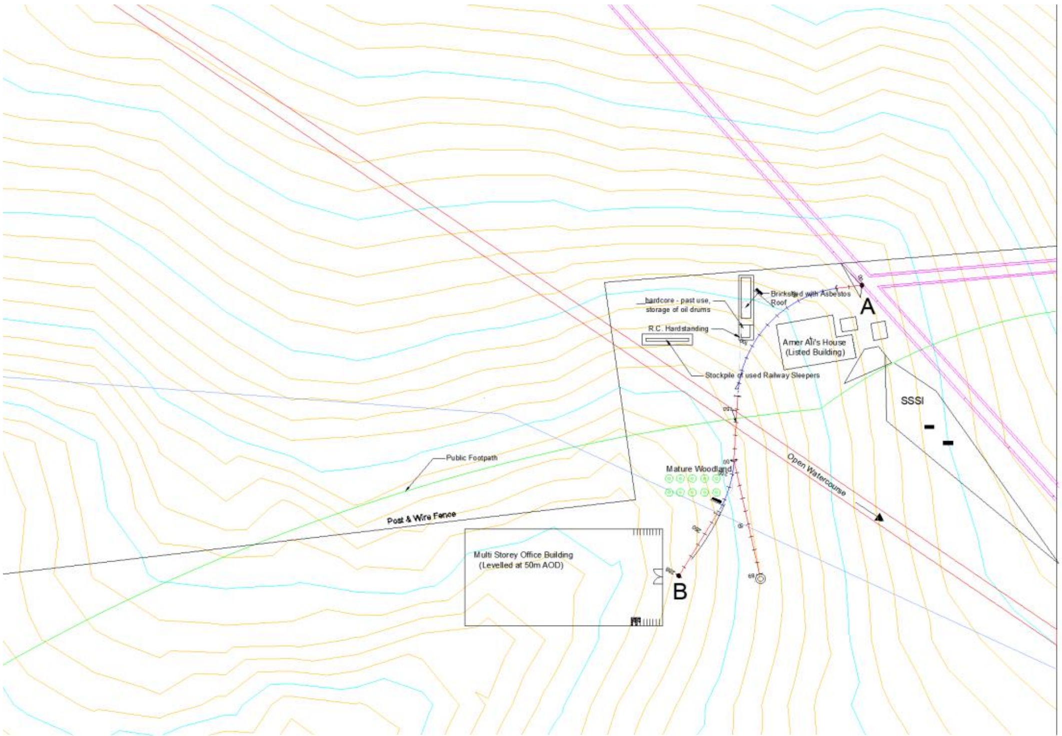
HSE. 2018. *Health and Safety*. [ONLINE] Available at: http://www.hse.gov.uk/pubns/gs6.pdf. [Accessed 9 December 2018].

Leeds Government. 2018. *Street Design Guide*. [ONLINE] Available at: https://www.leeds.gov.uk/docs/FPI_SDG_001%20Street%20Design%20Guide%20Final.pdf. [Accessed 8 December 2018].

Birmingham City Council. 2018. *Car Park Design Guide | Birmingham City Council*. [ONLINE] Available at: https://www.birmingham.gov.uk/downloads/file/1053/car_park_design_guide. [Accessed 11 December 2018].

Sites of Special Scientific Interest | Scottish Natural Heritage. 2018. *Sites of Special Scientific Interest | Scottish Natural Heritage*. [ONLINE] Available at: https://www.nature.scot/professional-advice/safeguarding-protected-areas-and-species/protected-areas/national-designations/sites-special-scientific-interest. [Accessed 11 December 2018].


PROFILE VIEW
SCALE: H 1:500,V 1:100. DATUM: 50.000
Level
-3.87%
Chainage
00.000 10.000 20.000 30.000 40.000 50.000 60.000 70.000 80.000 90.000 100.000 110.000 120.000 130.000 140.000 150.000 160.000 170.000 180.000 190.000 200.000 210.000 220.000 230.000 240.000 250.000 260.000 270.000 280.000 287.619
Existing Levels
63.383 62.963 62.352 61.711 61.244 60.833 60.228 59.779 59.523 58.905 58.238 57.757 57.274 56.787 56.568 56.368 56.168 55.839 55.578 55.505 55.395 55.208 54.745 54.242 53.770 53.351 53.042 52.733 52.447 52.255
Horizontal Geometry
L =19.236
R: 87.588
L: 120.804
L =48.718
R: 87.801
L: 43.675
L =55.186
Vertical Geometry


hardcore - past use, storage of oil drums
R.C. Hardstanding
Brickshed with Asbestos Roof
A
Amer Ali's House (Listed Building)
Stockpile of used Railway Sleepers
SSSI
Public Footpath
Mature Woodland
Open Watercourse
Post & Wire Fence
Multi Storey Office Building (Levelled at 50m AOD)
B