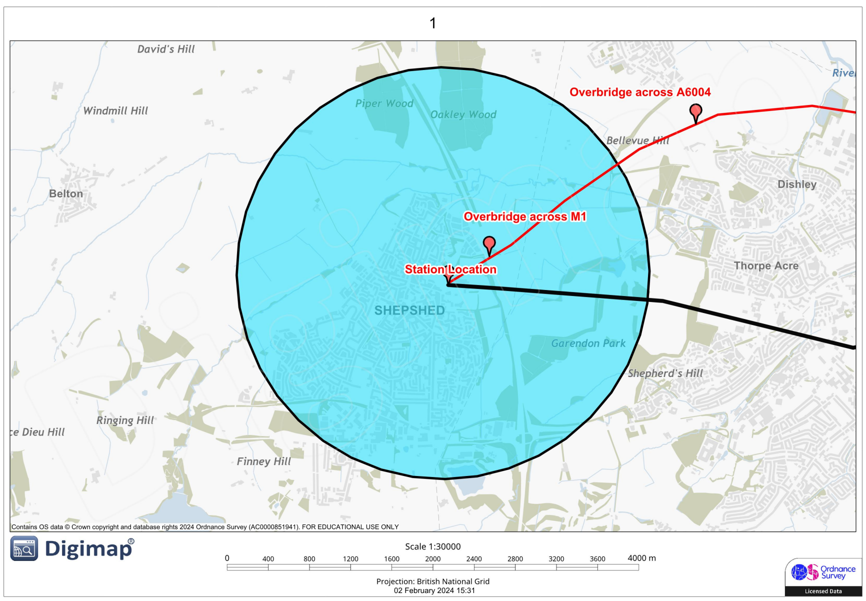
Task 1

a)

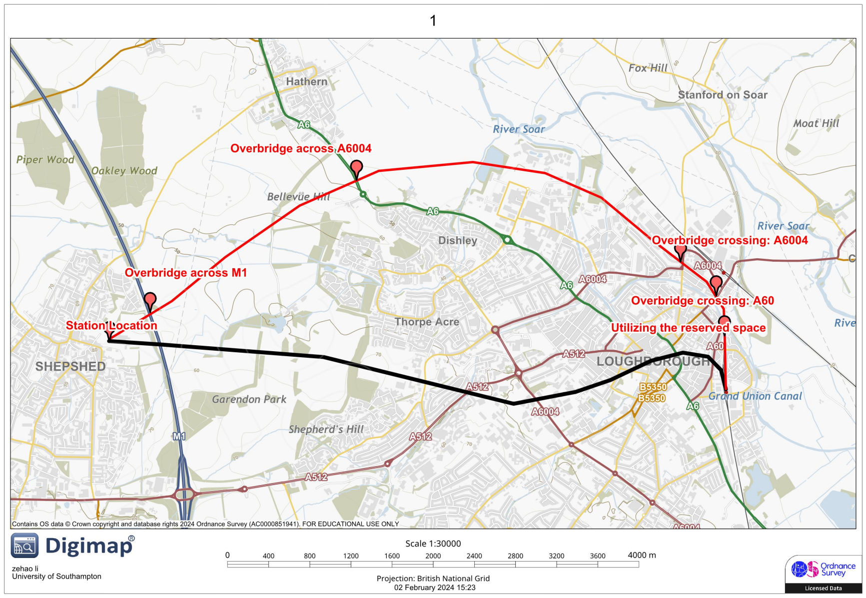
1. Location of the new station

The new SHEPSHED station is located in eastern suburbs of the town, an area with sparse residential development, which circumvents the high demolition costs typically associated with urban station constructions. Crucially, its position ensures that the vast majority of the town is accessible within a 2000-metre radius, making it an optimal site for the station.



1. Route direction

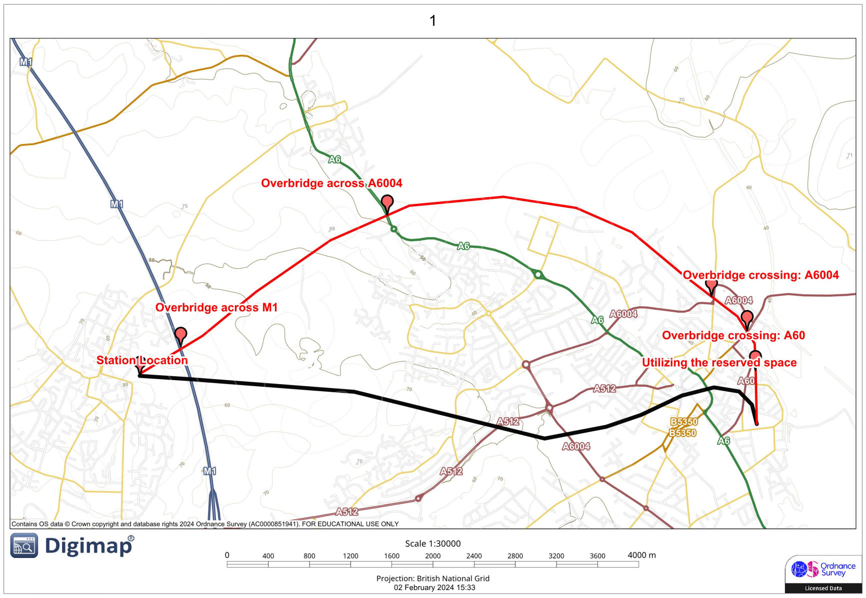
The proposed route outlined in red in Fig X, bypassed Loughborough to the north. The detour, while lengthening the journey and navigating challenging elevations in the northwest, significantly increases construction costs with respect to excavation and filling works. However, this route minimizes disruptions to the urban road network, meeting key stakeholder expectations. Importantly, it enhances operational efficiency by eliminating the need for speed reductions at Loughborough Central Station, a critical advantage for maintaining optimal transit times. This alignment represents a deliberate trade-off, prioritizing operational and community benefits over the increased direct costs and construction complexities.



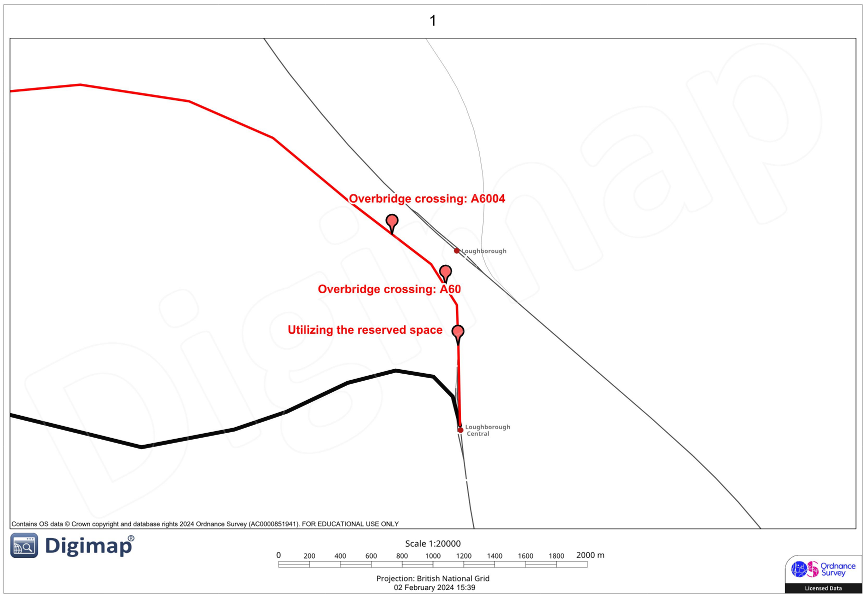
1. key control points

The design incorporates two types of control points to seamlessly integrate with existing infrastructure:

1. **At Road Intersections**: To maintain traffic flow on major roads, the design replaces level crossings at intersections with bridges over the M1, A6004(west and east sides), and A60. This choice, although increasing construction costs, is justified by the bridges' minimal disruption to existing traffic patterns. By prioritizing bridges, the design significantly mitigates interference with the traffic infrastructure, demonstrating a balanced approach to cost and community impact.



1. **In Rail Connections**: Strategically, the design leverages the reserved rail line on the north side of Loughborough Central Station, which is possibly prepared for future connection with the northern Loughborough Station. This integration significantly reduces costs by utilizing the reserved space and improves operational efficiency through a smoother line shape.



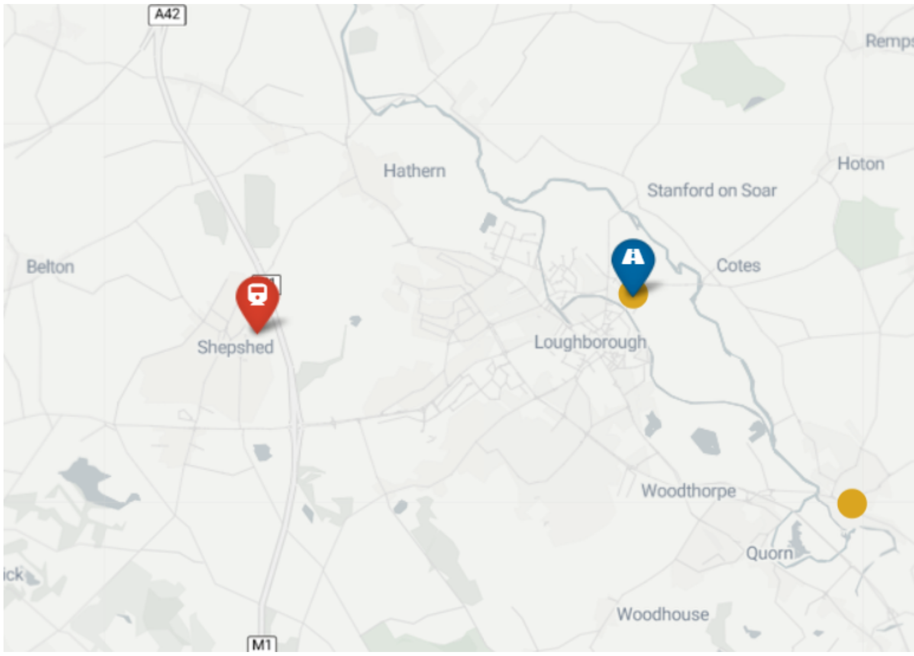
b)

Based on the obtained contour data, a gradient profile shown in Fig X is recommended, adhering to a maximum ratio of 1:50(for sections up to 3km). The profile reveals significant gradient changes, necessitating extensive earthwork. Such work increases costs and adversely affects the environment.

To mitigate these impacts, it is suggested to construct a tunnel approximately 800 metres long at the most challenging mountain segment, located between 2000 and 2500 meters along the route.

c)

By using the online tool Station Demand Forecasting Tool, it is predicted that the number of passengers using the new station in its year of opening year is 905215. The follow figures show the station location and the road access point.



The input values are shown in Table 1 and it should be noted that the Frequency is calculated using the following formula:

$$\begin{aligned}
\text{Frequency} &= 2 \times \left(\frac{\text{total_run_time_minutes}}{\text{interval_minutes}} + 1 \right) && (1) \\
&= 2 \times \left(\frac{18 \times 60}{40} + 1 \right) && (2) \\
&= 56 && (3)
\end{aligned}$$

id	3812
name	SHEPSHED
region	East Midlands
station_easting	448381
station_northing	319786
access_easting	454346
access_northing	319361
frequency	56
frequency_group	NA
parking_spaces	100
ticket_machine	TRUE
bus_interchange	TRUE

id	3812
cctv	TRUE
terminal_station	TRUE
travelcard_boundary	FALSE
category	E

d)

For commuters

$$\text{Commuter Ratio} = \left(\frac{8.7}{8.25}\right)^{-0.6} \times \left(\frac{26+23}{26+27}\right)^{-0.6}$$
$$\text{Commuters in base year} = 0.40 \times 905215$$
$$\text{Commuters in 2035} = \text{Commuters in base year} \times \text{Commuter Ratio}$$

For business:

$$\text{Business Ratio} = \left(\frac{8.7}{8.25}\right)^{-0.7} \times \left(\frac{26+23}{26+27}\right)^{-0.6}$$
$$\text{Business Travelers in base year} = 0.15 \times 905215$$
$$\text{Business Travelers in 2035} = \text{Business Travelers in base year} \times \text{Business Ratio}$$

For leisure:

$$\text{Leisure Ratio} = \left(\frac{8.7}{8.25}\right)^{-1.3} \times \left(\frac{26+23}{26+27}\right)^{-0.6}$$
$$\text{Leisure Travelers in base year} = 0.45 \times 905215$$
$$\text{Leisure Travelers in 2035} = \text{Leisure Travelers in base year} \times \text{Leisure Ratio}$$

Therefore, the number of travelers in 2035 is 903271.

Task 2

1)

Based on Task 1, the frequency of trains passing through this route has been calculated. If we consider only one direction (for example, from Shepshed to

Loughborough), there are 28 train services per day. Therefore, we can calculate the annual number of vehicle passes from Shepshed to Loughborough as follows:

$$\textit{the annual number of vehicles passes} = 3 \times 365 \times 28 = 30660$$

According to the results found on the official website, there are 41 train services from Southampton Airport Parkway to London Waterloo per day, resulting in an annual number of vehicle passes of 44,895. Comparing this with the new route design, we can observe two main differences in the train service from Southampton to London. First, the frequency of trains increases during peak hours in the morning and evening. Second, at certain times within these peak periods, the service operates two trains simultaneously—one fast and one slow. This design is flexible, tailoring the frequency and intervals of departures to meet varying travel demands at different times. It's an approach worth learning from and applying

National Rail Enquiries

Your personal journey from Southampton Airport Parkway to London Waterloo
Valid from Wednesday 14 February 2024 to Monday 19 February 2024

Monday to Friday always runs
Outward

		SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
Southampton Airport Parkway	dep.	12:08	12:38	13:08	13:38	14:10	14:38	15:08	15:38	16:08	16:38	17:08	17:38
London Waterloo	arr.	13:21	13:49	14:21	14:49	15:20	15:49	16:21	16:49	17:24	17:51	18:20	18:49
Duration		1:13	1:11	1:13	1:11	1:10	1:11	1:13	1:11	1:16	1:13	1:12	1:11
Changes		0	0	0	0	0	0	0	0	0	0	0	0
Seating Class		1st	1st	1st	1st	1st	1st	1st	1st	1st	1st	1st	1st
Catering													

		SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
				1	2 OT		3	4 OT	5	6 OT	7 OT	
Southampton Airport Parkway	dep.	18:08	18:38	19:08	19:08	19:38	20:08	20:08	20:38	20:38	20:38	21:07
London Waterloo	arr.	19:20	19:51	20:20	20:24	20:49	21:29	21:30	21:49	21:51	21:52	22:22
Duration		1:12	1:13	1:12	1:16	1:11	1:21	1:22	1:11	1:13	1:14	1:15
Changes		0	0	0	0	0	0	0	0	0	0	0
Seating Class		1st	1st	1st	1st	1st	1st	1st	1st	1st	1st	1st
Catering												

Monday to Friday always runs
Outward Continued

		SW	SW
Southampton Airport Parkway	dep.	21:38	22:08
London Waterloo	arr.	22:44	23:31
Duration		1:06	1:23
Changes		0	0
Seating Class		1st	1st
Catering			

elsewhere.

Your Pocket Timetables - National Rail Enquiries

2

In total, there are two types of soil failure the methodology is designed to prevent, Subgrade Progressive Sheer Failure and Excessive Subgrade Plastic Deformation, which can be represented by the following two figures.

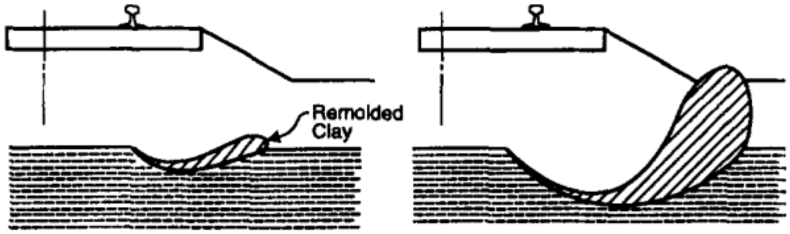


FIG. 2. Subgrade Progressive Shear Failure

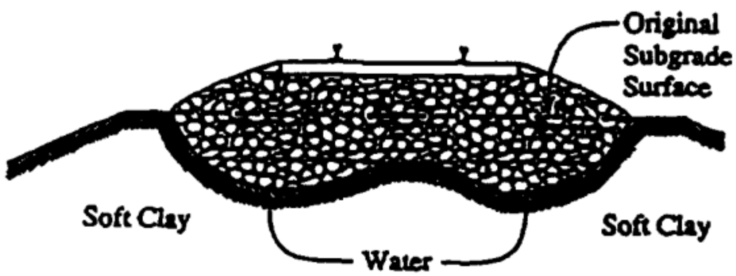


FIG. 3. Excessive Subgrade Plastic Deformation (Ballast Pocket)

Since we're using the fat clay(CH), the parameters are as follows: a=1.2, b=0.18, and m=2.4. The formula given is:

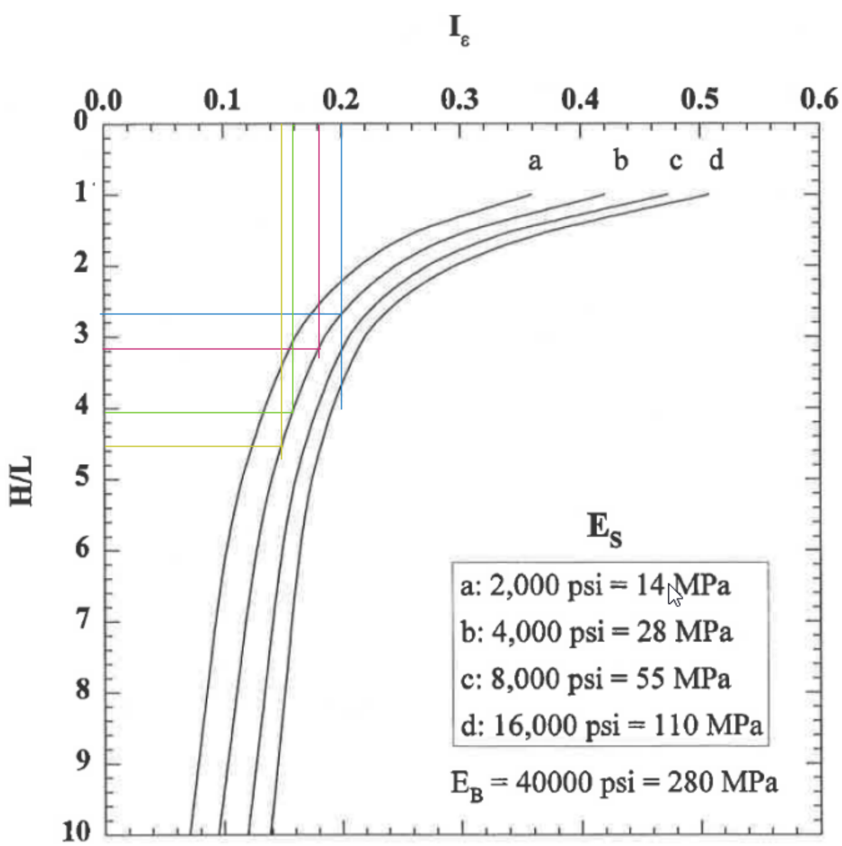
$$\epsilon = 1.2(\frac{\sigma_d}{\sigma_s})^{2.4} * N^{0.18}$$

$\frac{\sigma_d}{\sigma_s} \approx 0.586, 0.520, 0.461, 0.437 \because \sigma_s = 65\ kPa \therefore \sigma_d \approx 38.09, 33.8, 29.965, 28.405 kPa DAF = 1{+}0.052{\times}150/3.6/$

Student Name: Li,Zehao

Route ID number: 38

New station	Shepshed
County	Leicestershire
Region	East Midlands
Link to existing network	Loughborough
Train service pattern	Shepshed-Leicester
Base year service interval (mins)	40
Base year mean fare (£)	£8.25
Base year journey time	26 minutes
Line speed (km/h)	150
Parking spaces	100
2035 service interval (mins)	30
2035 mean fare (£)	£8.7
Undrained shear strength (C_u). This is also termed cohesive strength (σ_S) in some publications.	65 kPa



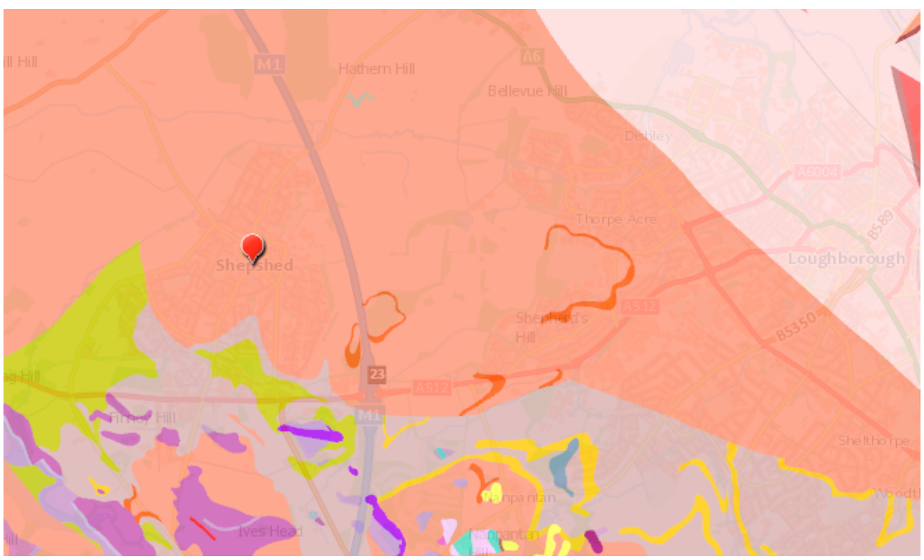
The final thickness is derived from the figure and is shown in the table:

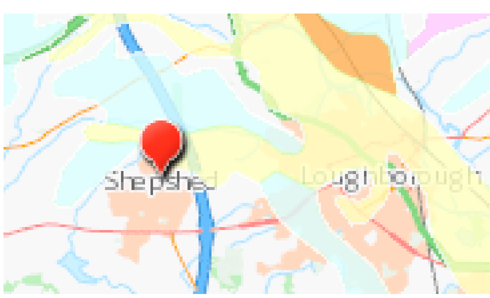
vehicle passes			I	H/L	H	Time(year)
200000	0.586	38.09	0.201928625	2.65	0.4028	6.523157208
1000000	0.52	33.8	0.17918581	3.19	0.48488	32.61578604
5000000	0.461	29.965	0.158855113	4.03	0.61256	163.0789302
10000000	0.437	28.405	0.150584998	4.56	0.69312	326.1578604

Assuming that ballast is replaced once every 30 years, I would suggest that a ballast thickness of 0.48m be used, a value that strikes a balance between engineering cost and durability.

3

The majority of the bedrock geology along the entire route is Mudstone(with subordinate dolomitic siltstone and fine-grained sandstone). The surface layer consists of Till, a mixture made up of clay and large rocks.





Due to the presence of clay at the surface, there's a higher likelihood of shear failure and excessive plastic deformation. This can be described using the Li and Selig methodThis means that the shear strength Es is relatively small and can be taken as one of 14, 28, 55 or 110 MPa.

4

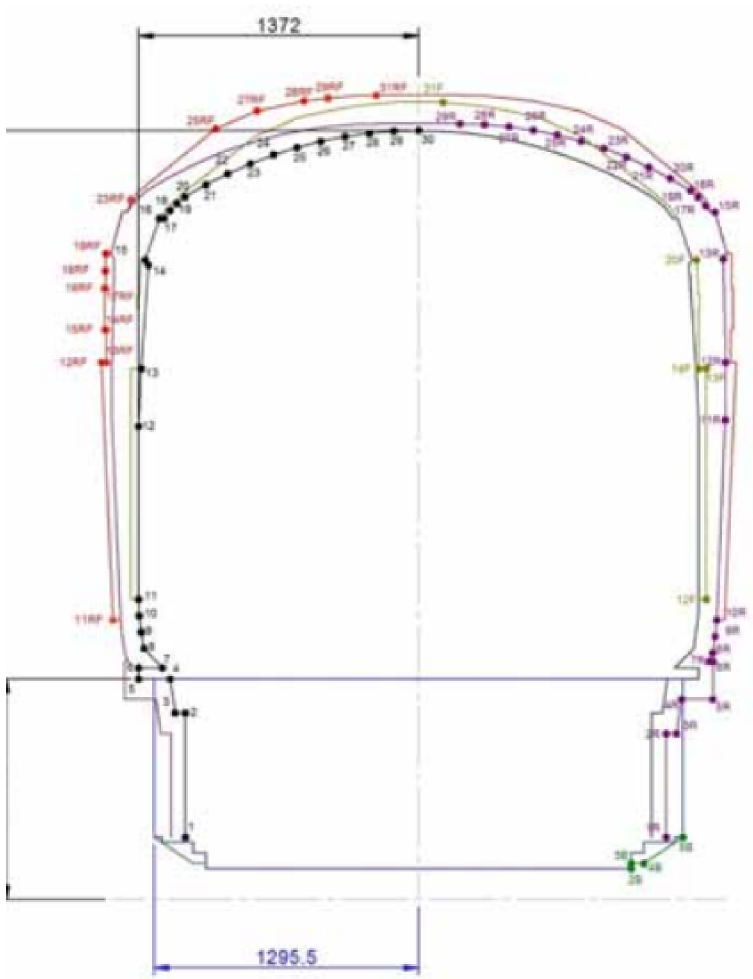
For granular subgrades, such as sands and gravels, or underlying rock, their strength is significantly higher than that of clay, making them less prone to progressive shear failure or excessive deformation due to deviator stress. As a result, the methods discussed in the paper are not suitable for these types of subgrades. When designing for these materials, one should consider the thickness of the granular layer from the perspective of other types of failures, such as slope stability collapse or excessive consolidation settlement caused by the material's self-weight. For instance, by setting a critical value for a specific stress or strain indicator based on the critical conditions under which these problems occur, the designed thickness should ensure that the operational values of these indicators remain below the critical thresholds.

Task 3

a)

This new line is a short addition, about 7 kilometers (roughly 4.3 miles) in length, dedicated to passenger transport. Consequently, we've chosen the C1 type passenger vehicle standard gauge as outlined in "The V/S SIC Guide to British Gauging Practice." The C1 gauge is designed specifically for standard-length passenger vehicles, about 20 meters (approximately 65 feet) long, though versions for shorter vehicles also exist. These vehicles typically feature traditional metal spring suspension systems, with a standard bogie center spacing of 14 meters. Details about the vehicle design and gauge limits are illustrated in the accompanying diagram.

> http://www.rssb.co.uk/Library/groups-and-committees/2013-guide-vehicle-structure-sic-guide-to-british-gauging-t926.pdf



C1 Gauge

For the tunnel constructed at the 2000-meter mark of the new line, it's crucial to maintain a minimum distance of 100mm between the vehicle's loading gauge and the tunnel, which is the recommended clearance. This ensures that, even under the most adverse conditions, there's no risk of collision, a vital consideration for passenger safety. Maintaining infrastructure is equally critical to prevent deformation that could result in insufficient clearance.

Note that building a vehicle that truly meets C1 and can actually operate is going to be quite a challenge. This is mainly because air suspension allows for much more movement of the vehicle body than traditional steel springs do. Therefore, providing enough infrastructure space to accommodate suspension movement at all positions would be very costly. As a result, a dynamic measurement process was developed to allow the introduction of vehicles with air suspension.

b)

Based on the data retrieved from the Geoindex, along the predetermined route, there are two types of bedrock present. The first half of the route features mudstone, while the second half consists of both mudstone and siltstone. For the purposes of this analysis, the bedrock condition in the first half of the route is classified under the category of Murcia Mudstone:

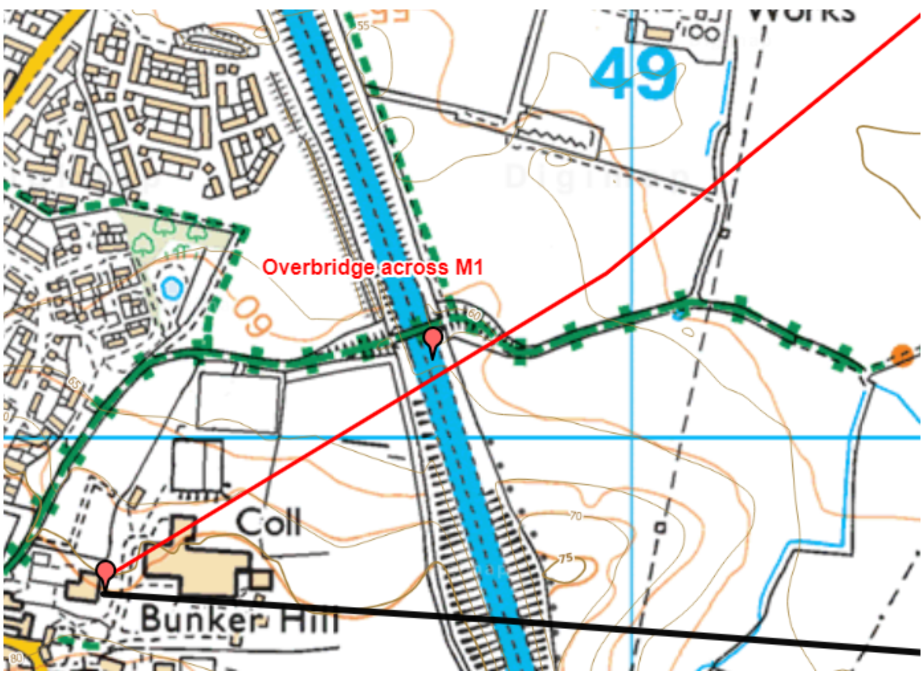
$$\phi = 30$$

c=5

$\gamma = 20$

For determining the elevation and slope, according to the route map, it's noted that at the 500-meter mark, there is a need to cross the M1 motorway. This will require an embankment(silt, clay) project. It can be assumed:

$$\beta = 15\ degrees, H = 6m$$



$$\frac{c'}{\gamma H} = \frac{5}{20 \times 6} = 0.042$$

the nearest table in the appendix, from Whitlow, is that for:

$$\frac{c'}{\gamma H} = 0.050$$

$\phi' = 20$

cot$\beta = 3.73...4 : 1$

m=2.33,n=1.98

r$_u$ = 0.4

$\therefore F = m - n \times r_u = 2.33 - 0.4 \times 1.98 = 1.538$

The safety factor is greater than 1.25, indicating that the slope is stable. Calculations show that with a D value of either 1 or 1.25, the safety factor remains above 1.25. Therefore, it can be concluded that for embankment projects using mudstone, employing a slope ratio of 4:1 and a height of 6 meters is practical and feasible in engineering terms.