**OBJECT:**

Learning to draw zero-line and determining the best line are the first purposes of this project which included considering the number of horizontal curvatures and radii of curvatures according to best line.

**CONSTRAINTS:**

* The road is second class rolling type road.
* Design speed is 70 km/hr.
* Maximum gradient is 5%.
* Minimum radius of circle is 20 for drawing zero-line.
* At most five times radius of the circle can be changed for zero-line.
* Minimum radius of curvature is 200 m.
* At least two curvatures should be implemented to the road.

**PROCEDURE:**

1. Decide the project features: class of highway, design speed, terrain type.
2. Start to draw circles to determine zero-line from the starting point of project by giving a value to the radius of the circle.
3. Draw a line from the center of the circle to the intersection of counter lines and end of the circle. Do the same procedure until necessity of the change of the radius.
4. Repeat the same procedure from (2) by giving different values to the radius of the curvature if the zero-line cannot reach the end point area successfully.
5. Draw best lines with respect to zero-line.
6. Determine the number of the curvature and its radius according to best line.
7. Calculate the curvature values: central angle, chord length etc.
8. Check whether transition distance between two curvatures is suitable or not.
9. Determine new radius value if the transition distance (Ls) is unsuitable.

**CALCULATIONS:**

*Gradient(g)*

*Radius of the circle in zero-line (r)*

*Transition distance (LS)*

*Angle (Δ)*

*V= 70 km/hr*

***Gradients:***

*gmax=5%*

*gi= 100/ri %*

*r1=20 m*

*g1 = 100/r1=100/20 = 5% = 5%*

*r2=30 m*

*g1 = 100/r1=100/30 = 3.33% < 5%*

*r3,=40 m*

*g2 = 100/r2=100/40 =2.5 % < 5%*

*r4=60 m*

*g3 = 100/r3=100/60 =1.67 % < 5%*

***Curvature:***

*First curvature:*

*R=200 m*

*Δ =101.7070*



*LS=0.0354\*V3/R*

*LS= 0.0354\*703/200 = 60.711 > 45 take Ls=60.711 m*

*K=2R\*sin(∆/2) = 2\*200\*sin(101.7070/2)= 310.214 m*

*T=R\*tan(∆/2)= 200\*tan(101.7070/2)= 245.692 m*

*L=(π\*R)/180\*(∆)= (π\*200)/180\*101.7070= 355.024 m*

*E=R\*(1/cos(∆/2) -1) = 200\*(1/cos(101.7070/2)-1)= 116.804 m*

*M=R\*(1-cos(∆/2)) = 200\*(1-cos(101.7070/2))= 73.739 m*

*Second curvature:*

*R=250 m*

*Δ =47.6281*



*LS=0.0354\*V3/R*

*LS= 0.0354\*703/250 = 48.5688 > 45 take Ls=48.5688 m.*

*K=2R\*sin(∆/2) = 2\*250\*sin(47.6281/2)= 201. 885 m*

*T=R\*tan(∆/2)= 250\*tan(47.6281/2)= 110.336 m*

*L=(π\*R)/180\*(∆)= (π\*250)/180\*47.6281= 207.817 m*

*E=R\*(1/cos(∆/2) -1) = 250\*(1/cos(47.6281/2)-1)= 23.266 m*

*M=R\*(1-cos(∆/2)) = 250\*(1-cos(47.6281/2))= 21.285 m*

*Third curvature:*

*R=300 m*

*Δ =41.7793*



*LS=0.0354\*V3/R*

*LS= 0.0354\*703/300 = 40.474 < 45 take Ls=45 m.*

*K=2R\*sin(∆/2) = 2\*300\*sin(41.7793/2)= 213.942 m*

*T=R\*tan(∆/2)= 300\*tan(41.7793/2)=114.497 m*

*L=(π\*R)/180\*(∆)= (π\*300)/180\*41.7793=218.756 m*

*E=R\*(1/cos(∆/2) -1) = 300\*(1/cos(41.7793/2)-1)=21.107 m*

*M=R\*(1-cos(∆/2)) = 300\*(1-cos(41.7793/2))=19.719 m*

**DISCUSSION OF RESULTS:**

In this project the determination of g value is a crucial point to design an effective and economic highway. Therefore, the grade value is used as maximum 5 percent. After deciding to grade values according to the Turkish highway standards the project was continued with drawing of zero-line which helps us to determine an initial possible route for horizontal alignment which does not violate the gradient limitations. In the project, four different ‘g’ values used which are 5%, 3.33%, 2.5%, 1.67%. To support this grade, circles having 20 m, 30 m, 40 m, and 60 m were preferred respectively. By the help of zero-line, the exact route of highway route (best line) was created.

As a second step of project, to avoid sharp turning which cause risk with traveling a high velocity three horizontal curves were used to connect two points that are given. Minimum values should be 200 m according to Turkish highway standards and 200m, 250m and 300m radius of curvatures were used.

The transition distances (LS) were found as 60.711 m, 48.5688 m and 45m respectively. In the final curve since calculated transition distance is smaller than 45 m, the previous Ls value was omitted. Safety distances were checked according to these transition distances. Finally, considering measured deflection angles and radii, the curve elements (T, L, M, E, K) were calculated

**CONCLUSION:**

To sum up, as a civil engineering students, we introduced to the initial steps of how to design a highway project. Drawing zero-line and determining the best line concepts were learned. The importance of horizontal curves and the required distance between these curves were covered.

The classification, design speed and the terrain type of the highway are mentioned on the Turkish highway standards as ‘Class / Terrain Type / Design Speed’. The standards of the highway were determined according to these

Finally, this project includes general concept of CE 353 Principles of Transportation and Traffic Engineering course. We had a chance to make the usage of knowledge that is obtained in the lessons and recitations hours possible to apply. We are so excited to see the upcoming design steps.