Lab5: Highway Design

Due: Before midnight, Dec 2nd, 2007

The design lab will be applying engineering principles to a practical "real-world" situation. This will involve "trial and error" conditions. It is assumed that some work will have to be revised. A highway design package (`http://street.umn.edu/Road/GeometryDesign.html`) will assist in the design process. Outputs from this package will be used in your final report. Although the design package generates some constraints and parameters, all considerations and calculations should be presented in detail in your final report. The project may be done individually or with a partner. Both partners will receive the same score. Professional engineering standards and behavior are expected.

1 Problem Statement

The Forest Service requires a new Fire Tower for Ranger Bob to spot fires. This requires the construction of a new service road. The contour map shows the location. The road will begin near point C intersecting with the existing road at the marking (original ground surface elev. 1416.00 feet/431.6 m.). The service road will end at point D (original ground surface elev. 1410.00 feet/429.8 m.).

Ranger Bob will be the primary driver on this road and will get to test drive a new vehicle while on duty. The vehicle is called an "I3". The road will be designed to accommodate this vehicle. The vehicle characteristics are:

$$Mass 10,000kg$$
$$NominalPower 240kW$$
$$AvailablePower 92\%$$
$$FrontalArea 3.8m^2$$
$$DragCoefficient 0.5$$

The design speed of the road will be 100 km/hr. The air density is $1.2kg/m^3$. The gravitational force is $9.81m/sec^2$. These design criteria need to be used to determine the maximum grade of your roadway.

Your Project Manager in your office wants to see a worked out verification for some of your work. You need to include hand calculated verifications for maximum grade calculations, as well as verification (by hand calculation) that the curves (both vertical and horizontal) satisfy all design criteria.

2 Additional Design Information and Requirements for the New Road

- The road will be a two-lane rural road (i.e. one lane in each direction).

- The road must have at least one horizontal curve and at least one vertical curve.
- Lane width will be 3.66 m with lateral clearance of 1.9 m.
- Beginning elevation of the road at point C is 431.6 m.
- Ending elevation of the road at point D is 429.8 m.
- The road must avoid the wetlands, ponds, and creeks (waterways). In cases where you feel it is necessary to disrupt such features, you need to research what is done in practice and make recommendations as well as strongly justify your decision.
- Super-elevation of the road is a maximum of 0.06.
- Coefficient of side friction is 0.13.
- Coefficient of friction is 0.30.
- Maximum grade for road will be decided by the design criteria for the I3 but is not to exceed 0.07 (7%).
- The road must begin near point C with a flat grade for at least 90 m (300 feet).
- The road must end near point D with a flat grade for 90 m (300 feet).
- The road will consist of simple horizontal curves only.
- Maximum depth of cut and fill is 6m. If you do not meet this, you need to justify why.
- The road will be designed to minimize the amount of cut and fill.
- The road should have approximately equal amounts of cut and fill resulting in a mass balance as close as possible to zero (within $\pm 765 m^3$). If this is not met, you need to document why.
- Horizontal and vertical curve designs will be presented in Metric units.
- A highway design package (`http://street.umn.edu/Road/GeometryDesign.html`) will be used to assist the design process. Outputs from this package, including the horizontal profile and the vertical profile, the cut and fill analysis, a summary of geometric design, and etc, could be used in your final report. However, all considerations and calculations of design parameters should be presented in detail in your final report.
- The road will be designed and presented in professional engineering standards.

3 Assignment Schedule

- Week staring at Nov 5: Introduction of the project and software package, horizontal design.
- Week staring at Nov 12: Vertical design and mass diagram.
- Week staring at Nov 19: No lab (Thanksgiving).
- Week staring at Nov 26: Questions and answers, developing your final report.
- **Final report due: Before the midnight of Dec 2nd, by email to zhuxx120@umn.edu**.

4 Submission

A pdf file of a written report explaining the design task and your final design. Include:

- A cover page including: Title, CE 3201, Date, and Name(s).
- A project statement including: Description, Your considerations in the design, Constraints, etc.
- Your calculations for maximum grade determination,
- Verification of the suitability for one horizontal curve and one vertical curve (show that it meets all design criteria specified here and in your text). Show your calculations for minimum curve radius and minimum vertical curve length. A clean vertical profile and horizontal profile. Identify all curve points (both vertical and horizontal) and station them out.
  - Description of horizontal alignment
  - Explanation of variables and calculation
  - Contour sheet with horizontal alignment
  - Summary of Curve Data in a table form:
    - P.C.
    - P.I.
    - P.T.
    - R
    - L
    - T
  - ... Same for vertical alignment...
    - P.V.C.

    * Elev. P.V.C.
    * P.V.I.
    * Elev. P.V.I.
    * P.V.T.
    * Elev. P.V.T.
    * G1
    * G2
    * L

- A description of the mass diagram and hand calculations of the mass diagram for the first 300 meters 50 meter increments).
    - Description of mass diagram
    - Contour sheet with mass diagram
    - Demonstration of Cut-and-Fill calculation
- Summary
- Report should be named as: CE3201_lab5_yourname and in .pdf.

5 Grading Format:

TOTAL **100 points**
Correct and workable solution: Horizontal, Vertical, Mass Diagram **50 points**
Explanation of use of equations and tables: Horiz., Vert., Mass Diagram **30 points**
Presentation: Neatness, Effort, Quality **20 points**

6 Reference:

Handouts
Lecture notes
Textbook, chapter 6 and 7
On-line help for Highway Design