Project-2: Predicting Asphalt Strength, Deformation and performance properties

Due Date:1404-12-01

A- Description:

Design a TSK Fuzzy System to predict some properties of Asphalt.

This prediction is important since, Safety for motorists, bikers, and pedestrians is enhanced by accurately predicting properties of pavement layers to ensure the structural integrity of roads and highways. Moreover, resource allocation, scheduling, and quality control for road construction projects would be enhanced, leading to project success and durability of the infrastructure.

B- Dataset Description:

1. Binder (Asphalt Bitumen) Properties

These describe the **asphalt binder behavior**, especially stiffness and workability.

Viscosity (η) – Pa·s

- Measure of the **resistance to flow** of the asphalt binder.
- Higher viscosity → stiffer binder → better rutting resistance but harder to compact.

- Lower viscosity → easier mixing and compaction but can increase deformation risk.

2. Asphalt Content Parameters

These describe how much asphalt binder is in the mix and how effectively it coats aggregates.

% A.C. by weight (Pb)

- Total **asphalt cement content** by weight of the total mix.
- Critical for durability, strength, and moisture resistance.

% Effective Asphalt Content (Pbe)

- Portion of asphalt binder **not absorbed** by aggregates.
- This is the binder that actually contributes to **strength and durability**.
- Pbe = Pb − absorbed asphalt.

3. Density & Volumetric Properties

Maximum Theoretical Specific Gravity (Gmm)

- Density of asphalt mix **with zero air voids**.
- Used to calculate air voids and degree of compaction.

Unit Weight (kg/m³)

- Bulk density of compacted asphalt mix.
- Higher density usually means better compaction.

% Air Voids (Va)

- Percentage of air spaces in the compacted mix.
- Typical design target: **3–5%**
- Too low → bleeding
- Too high → moisture damage and cracking

4. Aggregate Gradation Parameters

These describe **particle size distribution**, which controls strength, voids, and workability.

P200 (% Passing)

- Percent of material passing the **0.075 mm sieve**.
- Represents mineral filler.

- Influences stiffness, moisture sensitivity, and workability.

P4 (Cumulative Percent Retained – 4.75 mm)

- Measures **coarse aggregate content**.

P38 (Cumulative Percent Retained – 9.5 mm)

- Indicates overall **coarse aggregate skeleton**.

P34 (Cumulative Percent Retained – 19 mm)

- Represents the **largest aggregate size fraction**.

5. Output: Strength & Deformation (Marshall Test Results)

These evaluate **load-carrying capacity** and **plastic deformation**.

Adjusted Stability (kN)

- Maximum load the specimen can withstand.
- Indicates **strength and resistance to rutting**.

Flow (mm)

- Deformation at maximum load.
- High flow → too soft
- Low flow → too brittle

6. Output: Performance-Based Mechanical Properties

These measure **stiffness under traffic loading**, especially for mechanistic design.

ITSM (Indirect Tensile Stiffness Modulus) – 20°C

- Stiffness of asphalt mix at moderate temperature.
- Higher values → better rutting resistance.

ITSM (Indirect Tensile Stiffness Modulus) – 30°C

- Stiffness at higher temperature.
- Lower values here indicate susceptibility to **rutting at hot conditions**.

C- Evaluation Metrics:

Randomly choose 80% of the dataset for designing and tuning the FS.

Evaluate the FS with the remaining 20% for testing the system.

Calculate and report RMSE for each of the outputs BOTH on test data and train data separately,

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(y^{(i)} - \hat{y}^{(i)}\right)^2}.$$

RMSE(flow), RMSE(Stability), RMSE(ITSM20), RMSE(ITSM30)

	RMSE(TrainData)	RMSE(TestData)
flow		
Stability		
ITSM20		
ITSM30		

D- What to Submit (zip all the following files-Name the zip file as: familyname-stdno.zip):

1- Source Code
2- A Report (.docx word file + pdf) containing:
  ▪ Detail description of the design method
  ▪ Detail description of how rules are generated

- Detail description of how fuzzy sets are generated
- Detail description of how TSK rules are tuned
- Results
- Interpretation of the obtained results
- Description of how to run the code
- Description of how to use the system as an end user

E- Important Notes:

1- You can use any feature selection/engineering method
2- You can design 4 separate Fuzzy systems for predicting each of the outputs separately.
3- If you use any AI tool, **explicitly** mention what AI tool is used for what purpose
4- Reports in English are accepted only if the summary of the report is provided in Farsi in at least **2 pages.** گزارش به زبان انگلیسی زمانی پذیرفته می شود که همراه با حداقل 2 صفحه (350 کلمه) خلاصه گزارش به زبان فارسی باشد.