CYCLIC STRESS RATIO (CSR) CALCULATION PROGRAM

This program computes the **Cyclic Stress Ratio (CSR)** at a specified depth using the *simplified earthquake-induced liquefaction analysis method*.

Working of the Program

1. Earthquake Input

The earthquake is defined by:

- Peak horizontal acceleration ratio, $a_{\max}/g$
- Earthquake magnitude, M

2. Soil Profile Definition

The soil profile consists of multiple layers, each defined by:

- Unit weight, γ_i
- Thickness, h_i

The total vertical overburden stress is computed as:

$$\sigma_{v0} = \sum_{i=1}^{n} \gamma_i \, h_i$$

3. Groundwater Conditions

The following groundwater parameters are used:

- Depth of water table from ground level
- Liquefaction check depth, z
- Unit weight of water, γ_w

Pore water pressure at depth z is computed as:

$$u_0 = \begin{cases} \gamma_w(z - z_{wt}), & \text{if } z > z_{wt} \\ 0, & \text{if } z \leq z_{wt} \end{cases}$$

4. Effective Vertical Stress

The effective vertical stress is given by:

$$\sigma'_{v0} = \sigma_{v0} - u_0$$

5. Stress Reduction Coefficient

The stress reduction coefficient accounts for the flexibility of the soil column and is computed as:

$$r_d = \exp(\alpha_z + \beta_z M)$$

where:

$$\alpha_z = -1.012 - 1.126 \sin\left(\frac{z}{11.73} + 5.133\right)$$

$$\beta_z = 0.106 + 0.118 \sin\left(\frac{z}{11.28} + 5.142\right)$$

6. Cyclic Stress Ratio

Finally, the Cyclic Stress Ratio is computed as:

$$CSR = 0.65 \left(\frac{a_{\max}}{g}\right) \left(\frac{\sigma_{v0}}{\sigma'_{v0}}\right) r_d$$

Important Notes

- All stresses are computed in kPa ($\mathrm{kN/m^2}$).
- Depths are measured from ground level.
- The liquefaction check point is assumed to lie below the water table unless stated otherwise.
- CSR is computed at a single depth location.