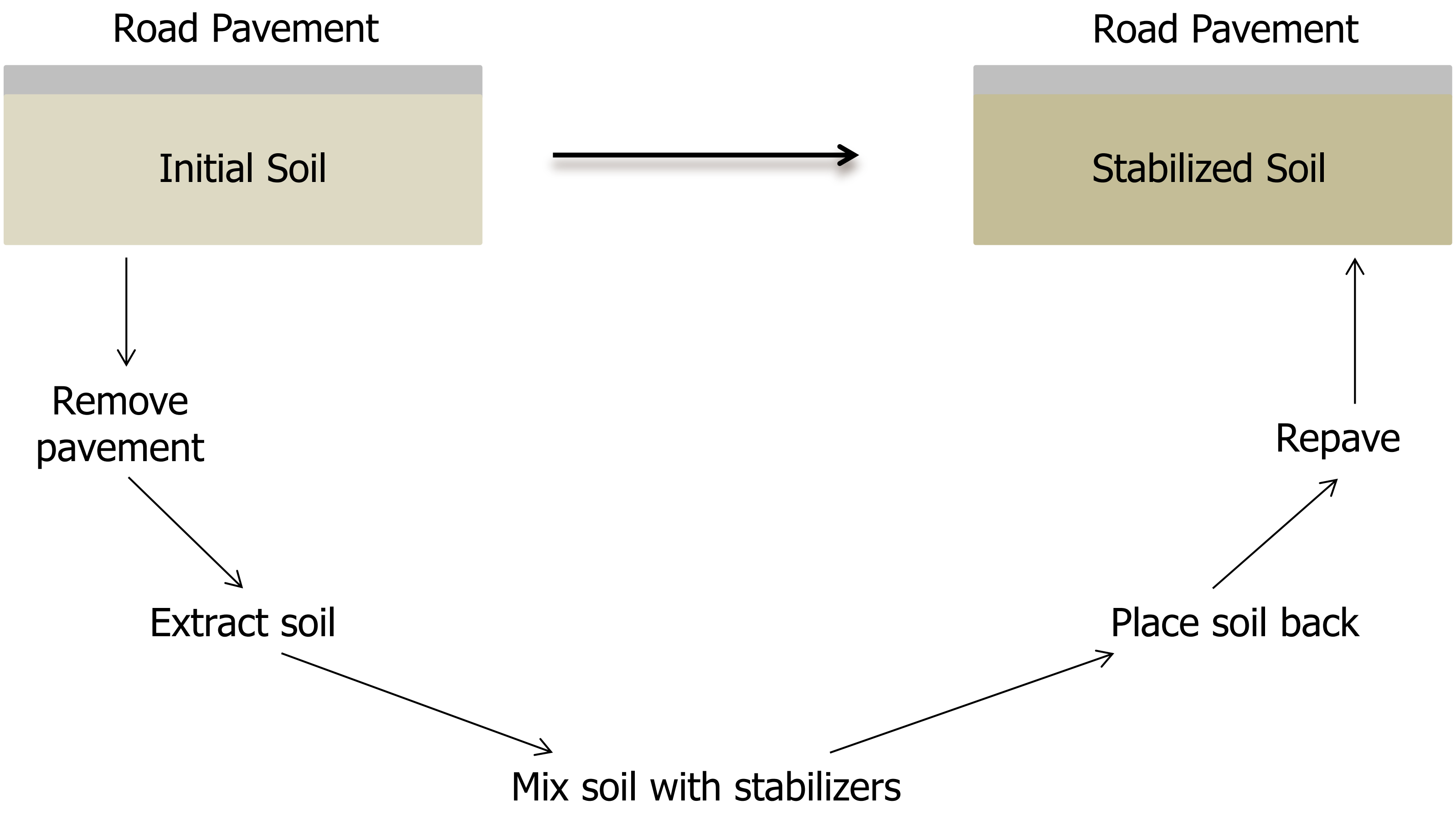
Mitigation of earthquake induced liquefaction under pavements via electrokinetic soil stabilization

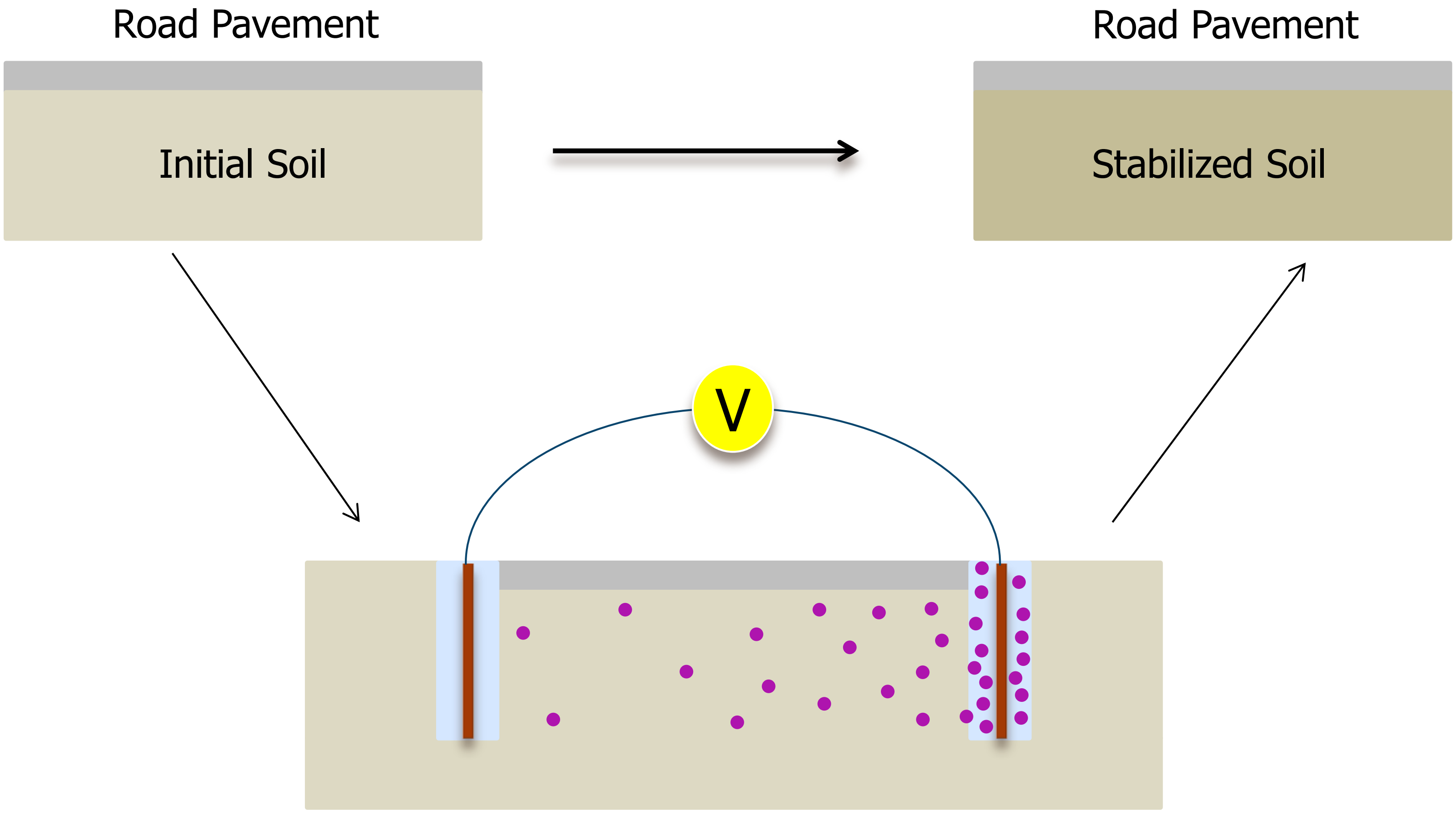
EQ induced liquefaction

- Prior to earthquake the pore pressure is low
- Earthquake causes pore pressure to increase: undrained conditions
- Effective stresses are reduced: loss of shear strength
- Loose soil particles: liquefaction occurs

Traditional soil stabilization



Electrokinetic soil stabilization (EKSS)



Governing equation for mass transport

The equation governing the concentration distribution (neglecting any reactions) is:

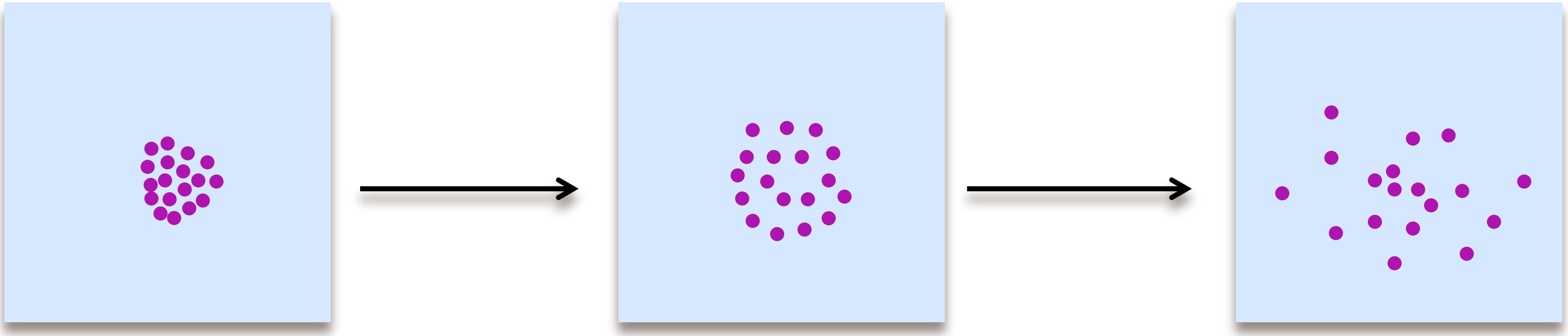
$$\frac{\partial c}{\partial t} = -\nabla \cdot \left(\underline{N}^{d} + \underline{N}^{m} + \underline{N}^{e}\right)$$

$\underline{N}^{d}$: Mass flux generated by diffusion

$\underline{N}^{m}$: Mass flux generated by electromigration (migration)

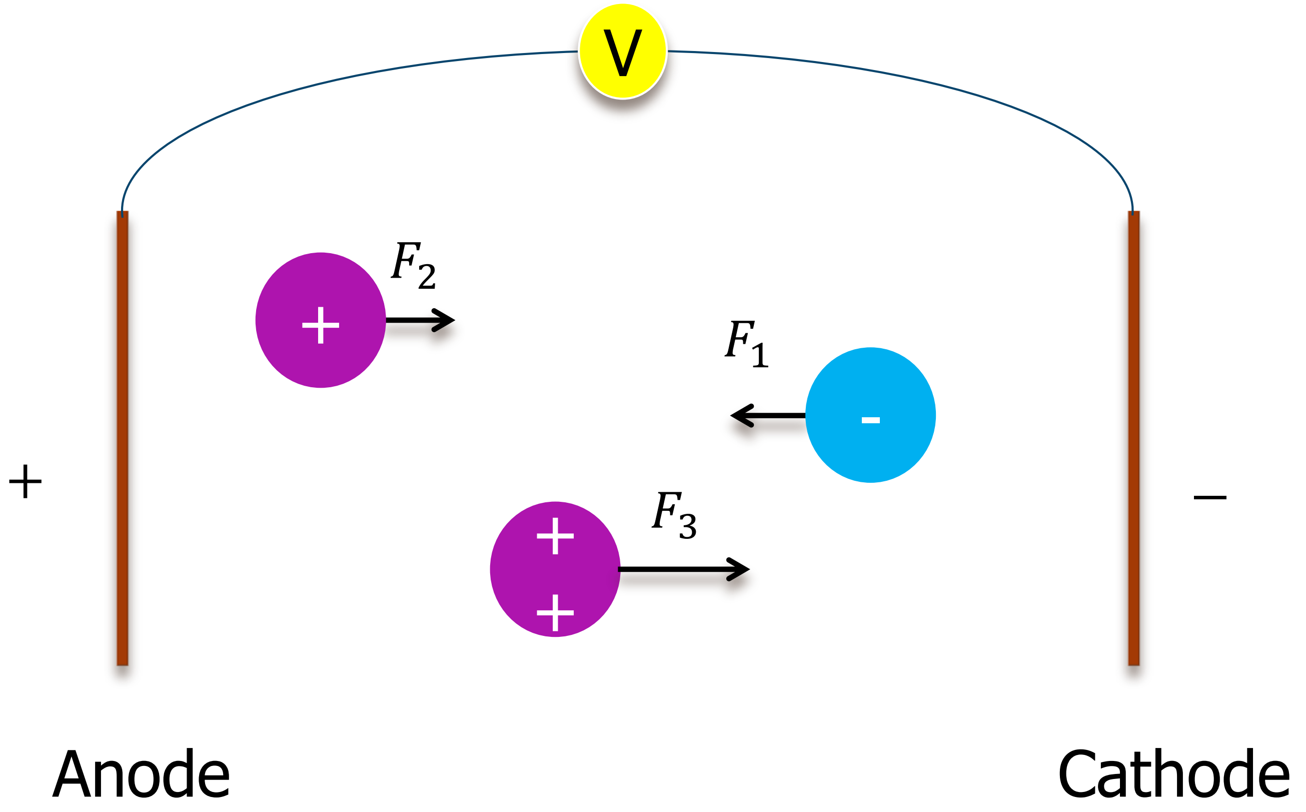
$\underline{N}^{e}$: Mass flux generated by electroosmotic advection

Diffusion

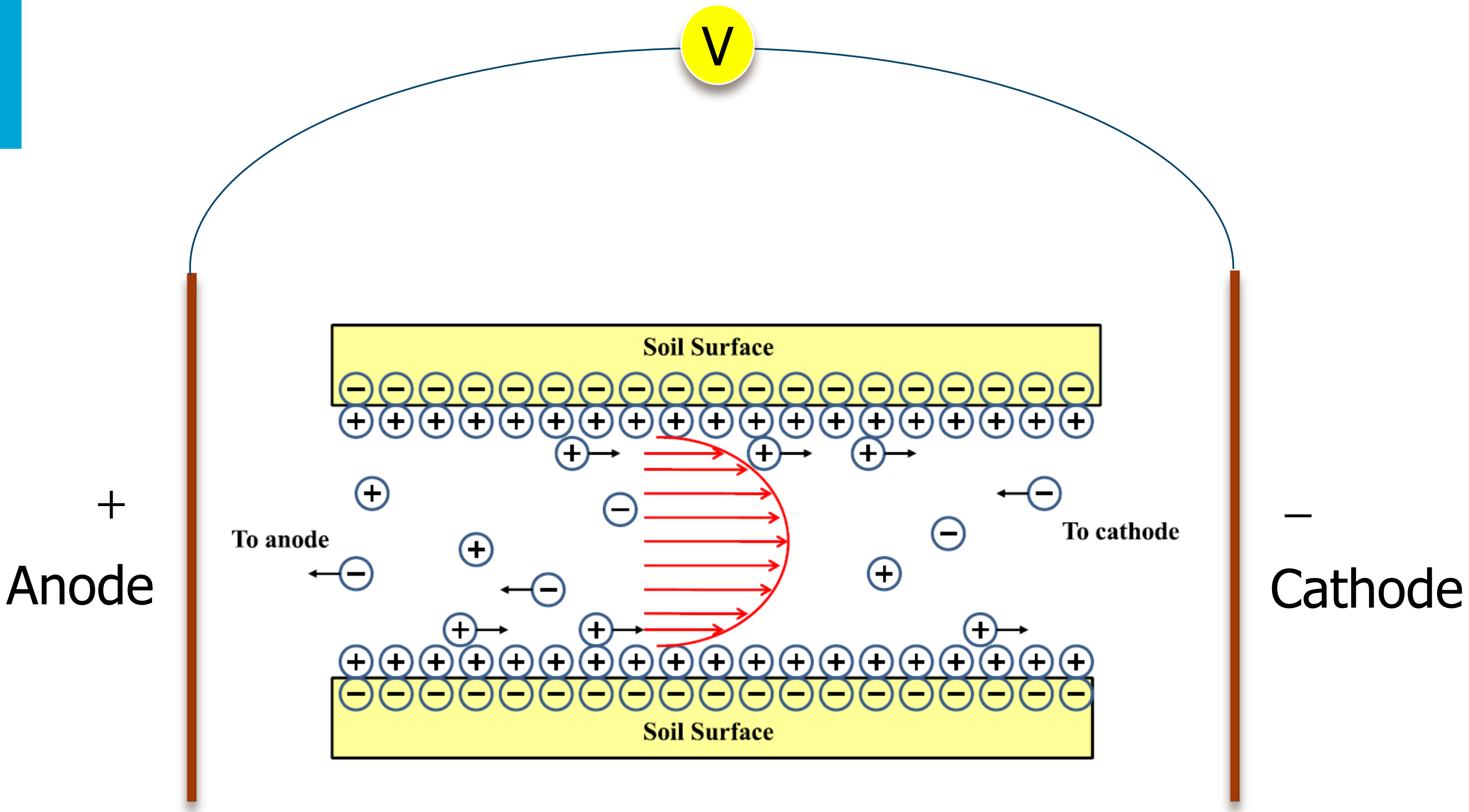


$t = t_0$ $t = t_1, \quad t_1 > t_0$ $t = t_2, \quad t_2 > t_1$

Electromigration (migration)



Electroosmotic advection



Governing equation for mass transport

$$\frac{\partial c}{\partial t} = -\nabla \cdot \left(\underline{N}^{d} + \underline{N}^{m} + \underline{N}^{e}\right) \quad \rightarrow$$

$$\frac{\partial c}{\partial t} = \frac{D^{0}\theta}{\tau^{2}} \Delta c + z_{c} F \frac{\theta}{\tau^{2}} \frac{D^{0}}{RT} \nabla c \cdot \nabla V - \frac{\varepsilon_{f}\zeta}{\tau\eta} \nabla V \cdot \nabla c$$

c:	Molar concentration	z_c:	Charge number/ Valence
t:	Time	F:	Faraday constant
D^0:	Diffusion coefficient	T:	Absolute temperature [K]
θ:	Volumetric soil water content	V:	Electric potential
τ:	Tortuosity	R:	Universal/ Ideal gas constant
ε_f:	Permittivity of the fluid	η:	Dynamic viscosity
ζ:	Zeta potential		

Numerical application