Study of Inertia Weight Parameter for Boundary Element Inverse Analysis to Detect RC Corrosion

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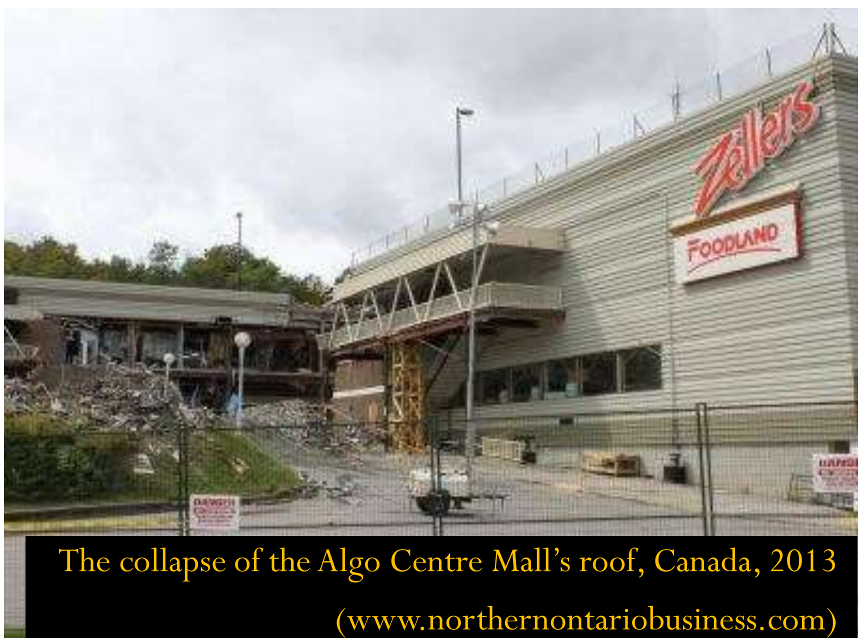
Corrosion of rebar

The failures of RC structures due to corrosion

A Bridge collapse (source: Material Performance, July 2000)

Overpass highway, Quebec, Canada, 2006 (www.ctv.ca)

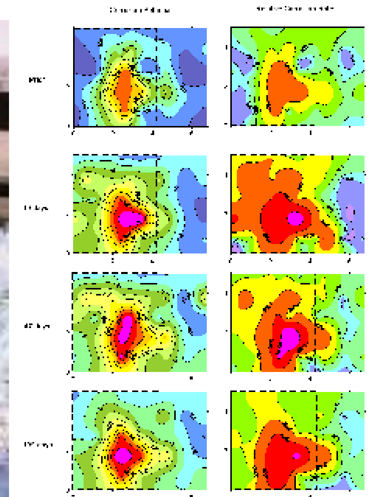


The collapse of the Algo Centre Mall's roof, Canada, 2013 (www.northernontariobusiness.com)

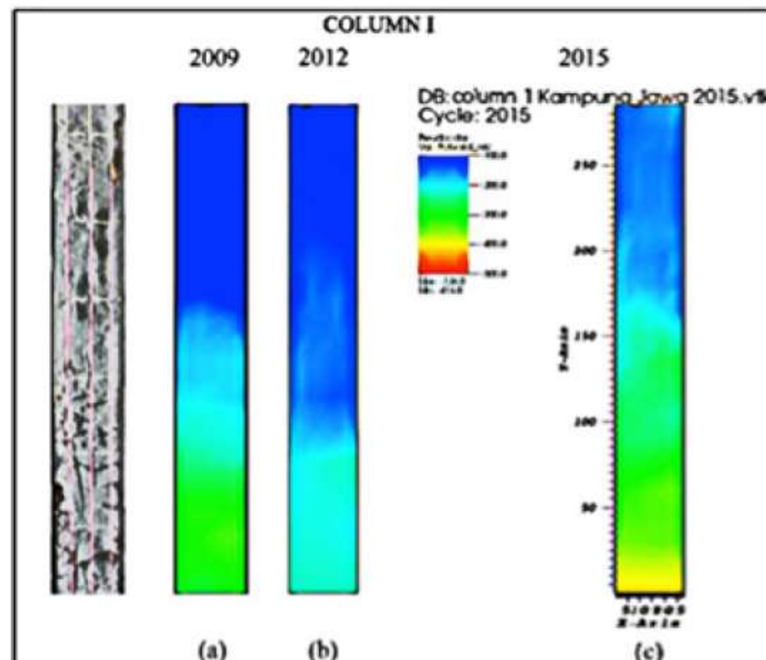
Jakarta, 25 September 2011 (http://megapolitan.kompas.com)

Direct Corrosion Monitoring

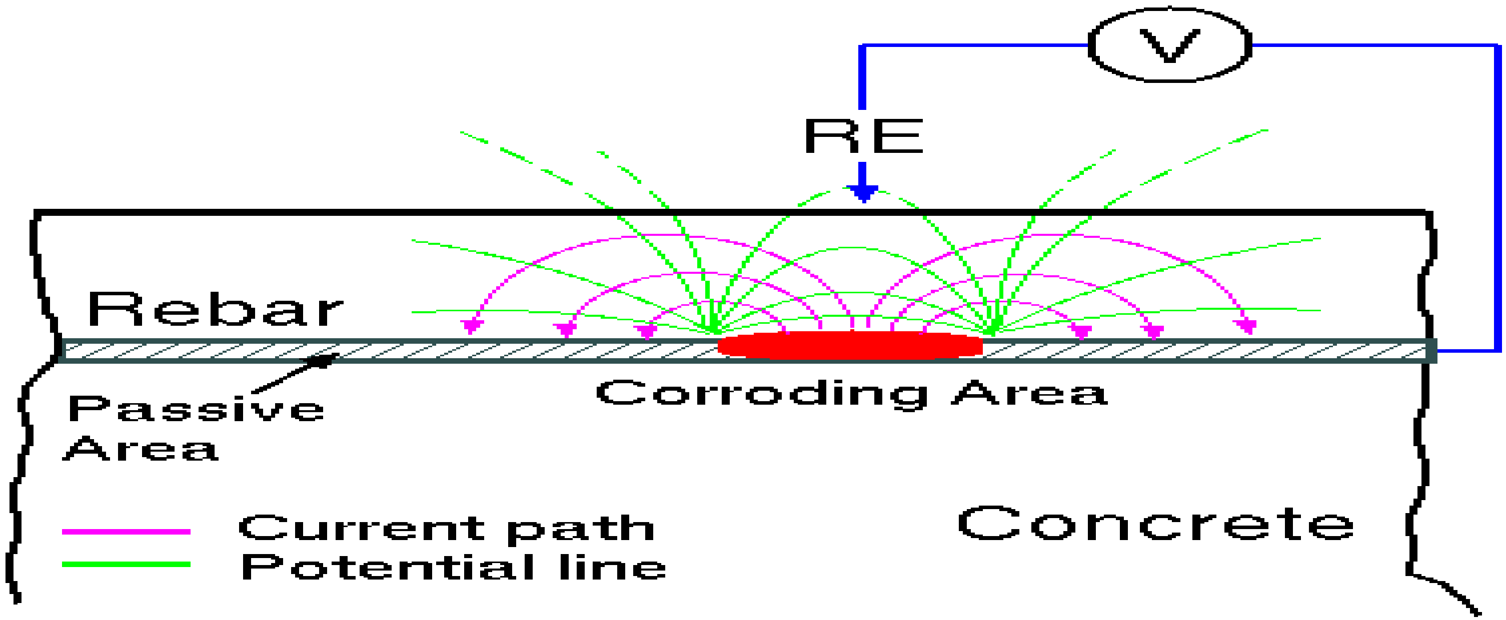
- Potential Mapping
- Concrete Resistivity



Kampung. Jawa, Banda Aceh



Limitation of Direct Analysis



Potential Mapping Method

- Less Accurate
- Laborious
- Time Consuming

Important !

Effective NDE Method

PROPOSED METHOD:

INVERSE ANALYSIS

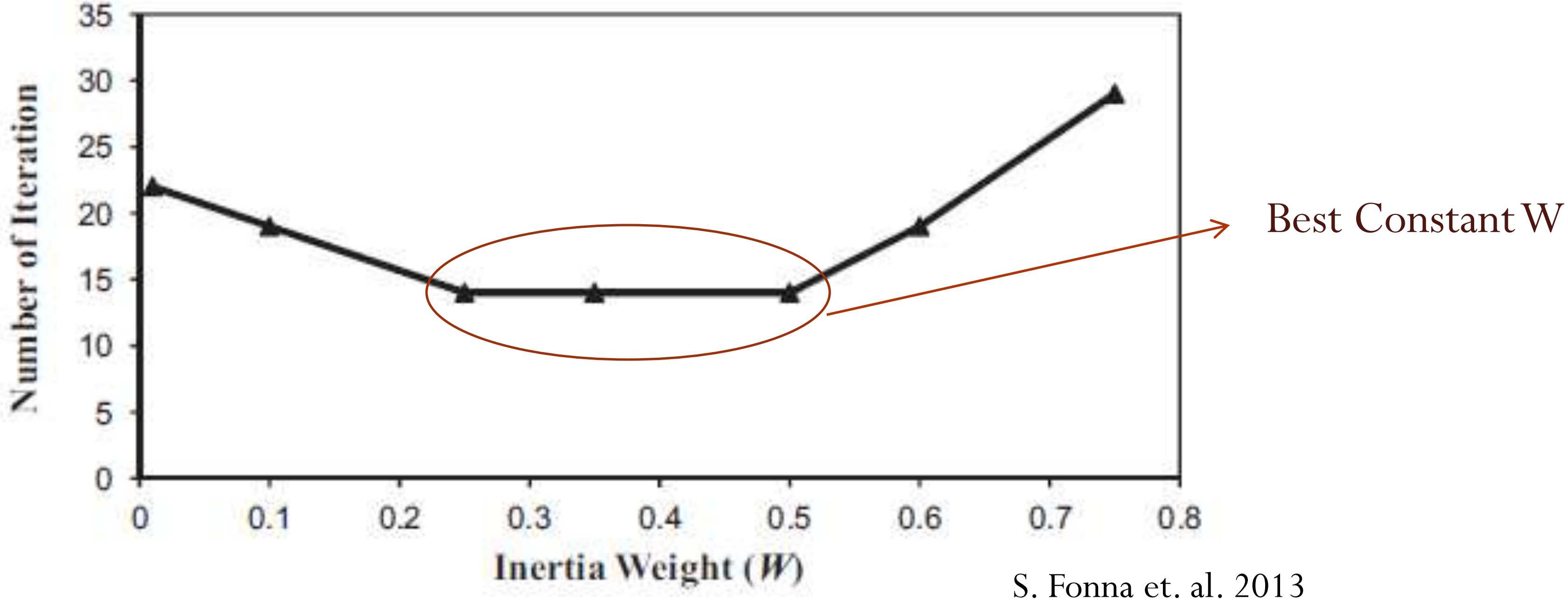
BOUNDARY ELEMENT METHOD

PARTICLE SWARM OPTIMIZATION

BOUNDARY ELEMENT INVERSE ANALYSIS (BEIA)

S. Fonna et. al. 2013

Previous study



S. Fonna et. al. 2013

Parsopoulos and Vrahatis (2010) suggested to use inconstant W for better result

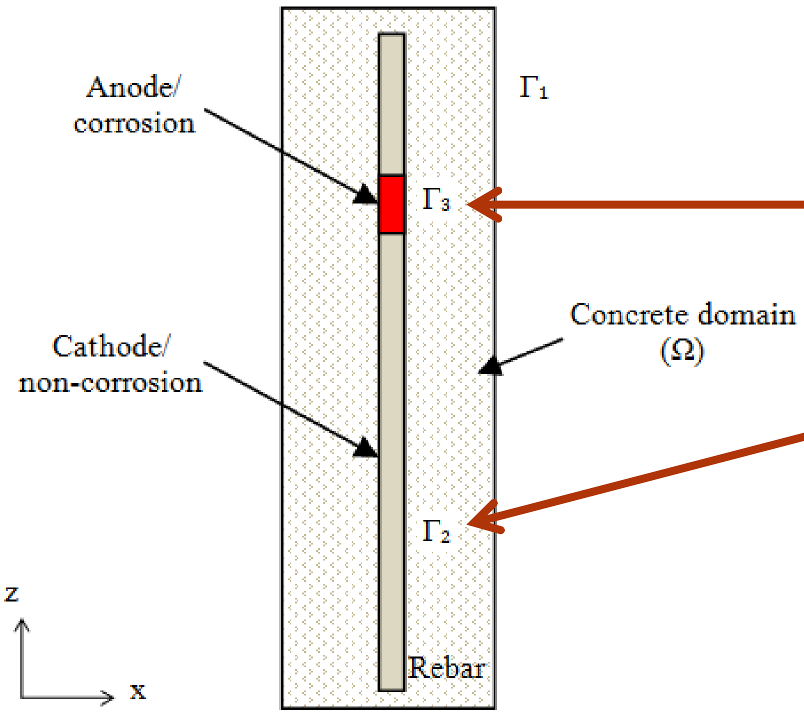
The purpose of this study:
To investigate the effect of inconstant W (with $W_{up} = 0.5$ and $W_{low} \leq 0.5$) on the performance of BEIA in detecting rebar corrosion in concrete

Modeling of Corrosion Problems

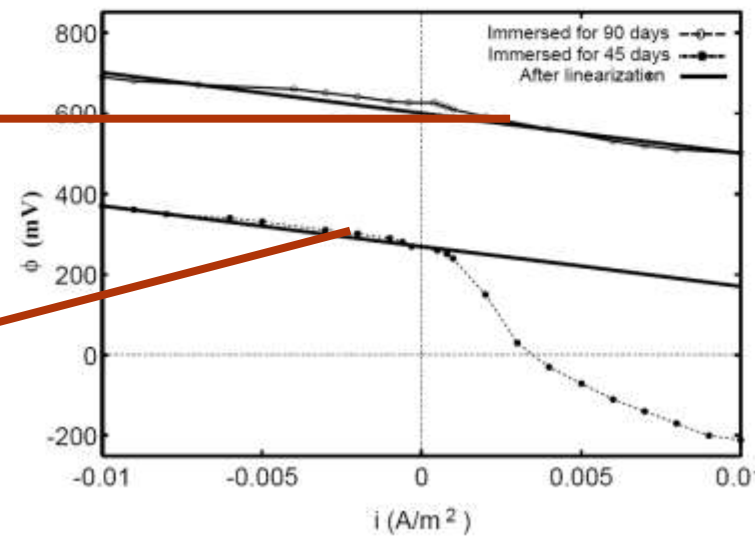
Laplace's Equation

$$\nabla^2\phi = \frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = 0$$ In Ω

Boundary conditions:



Polarization curve:

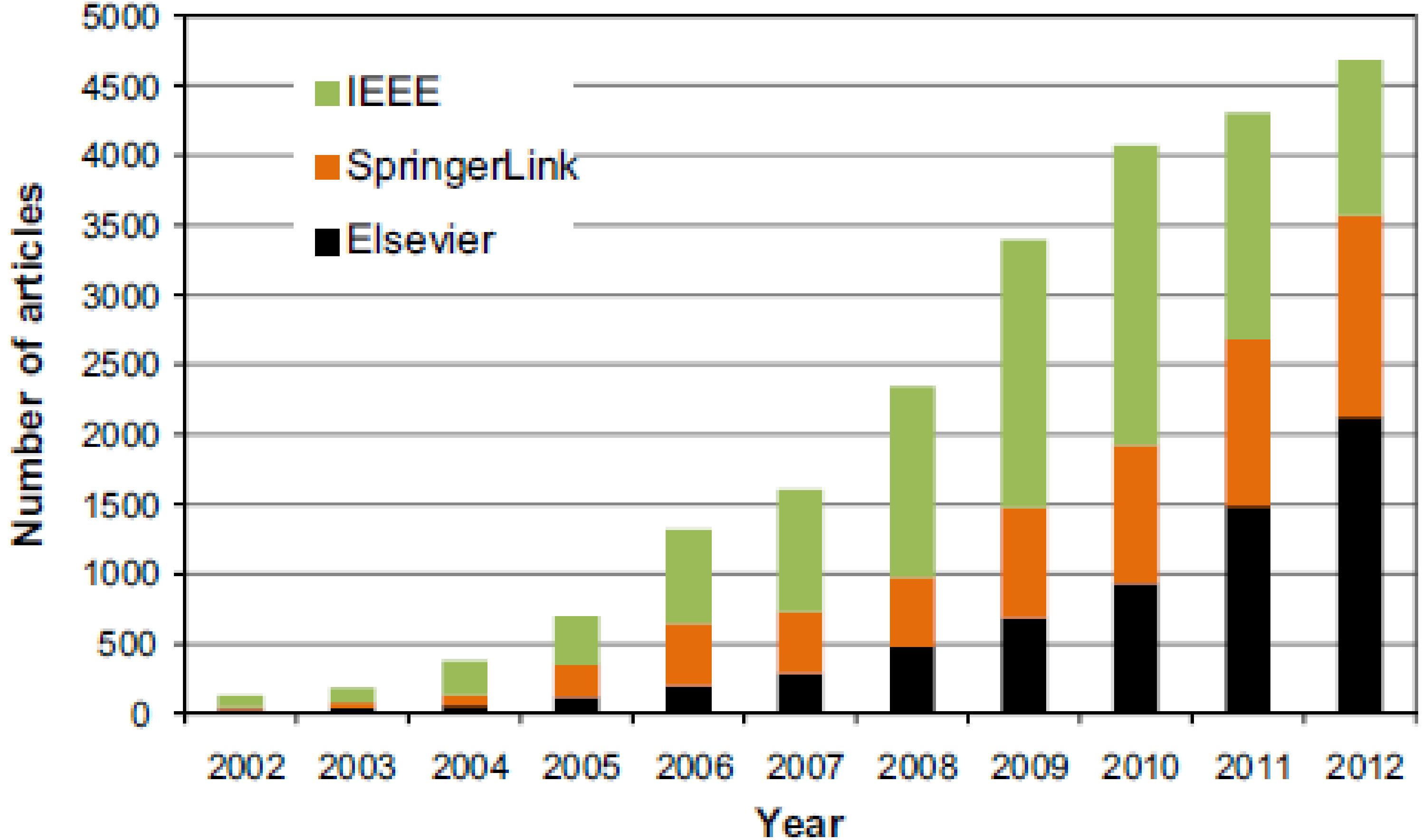


Ridha et al. 2005

BEM: Solving the Laplace's Eq.

Obtain: ϕ and i in the whole Ω

WHY PSO ???



S. Fonna et. al. 2013

- Simple algorithm
- Comparable accuracy

Particle Swarm Optimization

- Introduced by kennedy and eberhart in 1995
- Population-based search algorithm
- Inspired by flocking behavior of birds

Peudocode of PSO

Input:	Number of particle (Z), Swarm (S), best position (P)
Step1.	**Set** $j \leftarrow 1$
Step 2.	**Initialize** S and **Set** $P \equiv S$ Calculate W using Eq. c
Step 3.	**Evaluate** S and P, and define index g of the best position
Step 4.	**While** (termination criterion not met)
Step 5.	**Update** S using Eq. a and b
Step 6.	**Evaluate** S
Step 7.	**Update** P and redefine index g
Step 8.	**Set** $j \leftarrow j+1$
Step 9.	**End While**
Step 10.	**Print** best position found

$$X_{j+1} = X_j + V_{j+1} \quad \text{(a)}$$

$$V_{j+1} = W_j V_j + a_1 r_1 (pbest - X_j) + a_2 r_2 (gbest - X_j) \quad \text{(b)}$$

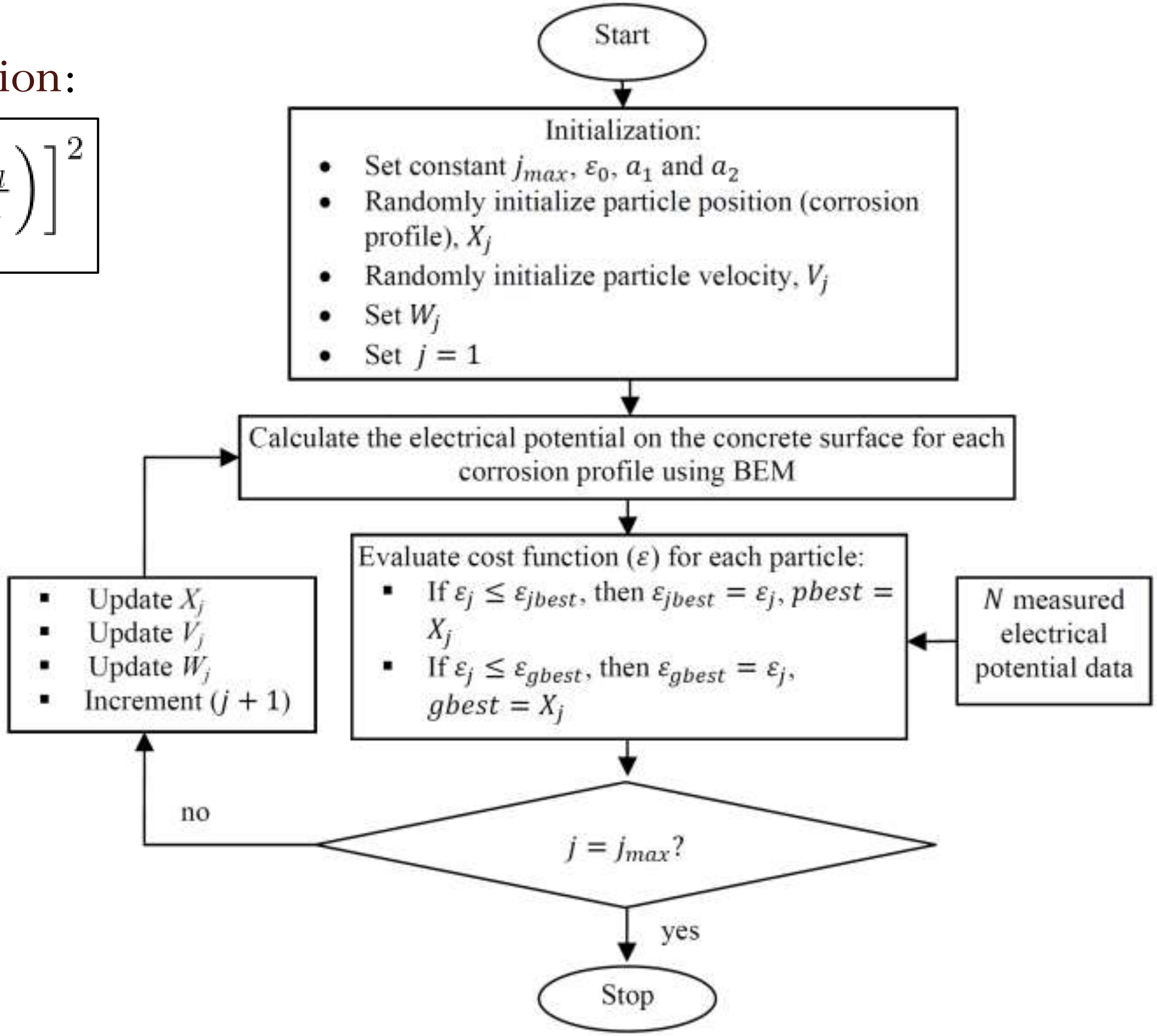
$$W_j = W_{up} - \left[(W_{up} - W_{low}) \frac{j}{j_{max}} \right] \quad \text{(c)}$$

Boundary Element Inverse Analysis

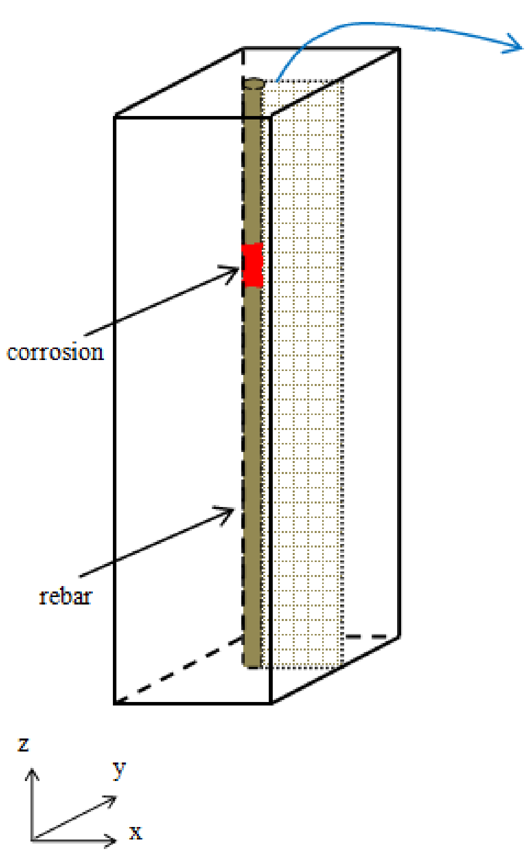
Minimize cost function:

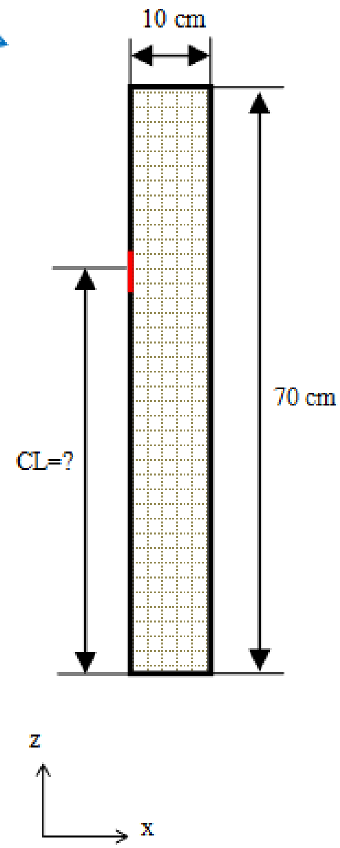
$$\varepsilon(C) = \sum_{l=1}^{N} \left[\left(\frac{\phi_l - \bar{\phi}_l}{\phi_{max}} \right) \right]^2$$

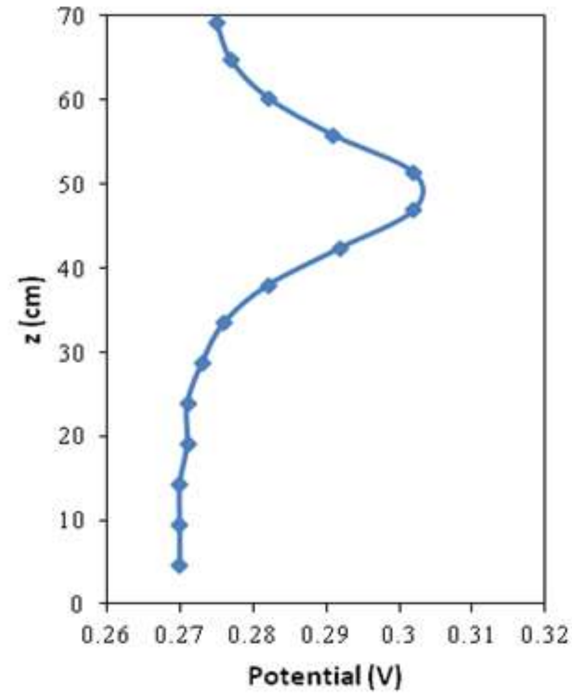
The flowchart of inverse analysis using PSO



Numerical Simulation Setup, Results and Discussion







$\kappa = 0{,}007\ \Omega^{-1}\mathrm{m}^{-1}$; $\varepsilon_0 \leq 10^{-4}$; $a_1 = a_2 = 0.5$; and $N = 15$ — Constant parameters

$$\phi_a = 0.600 - 10i \quad \text{(V)}$$
$$\phi_c = 0.270 - 10i \quad \text{(V)}$$

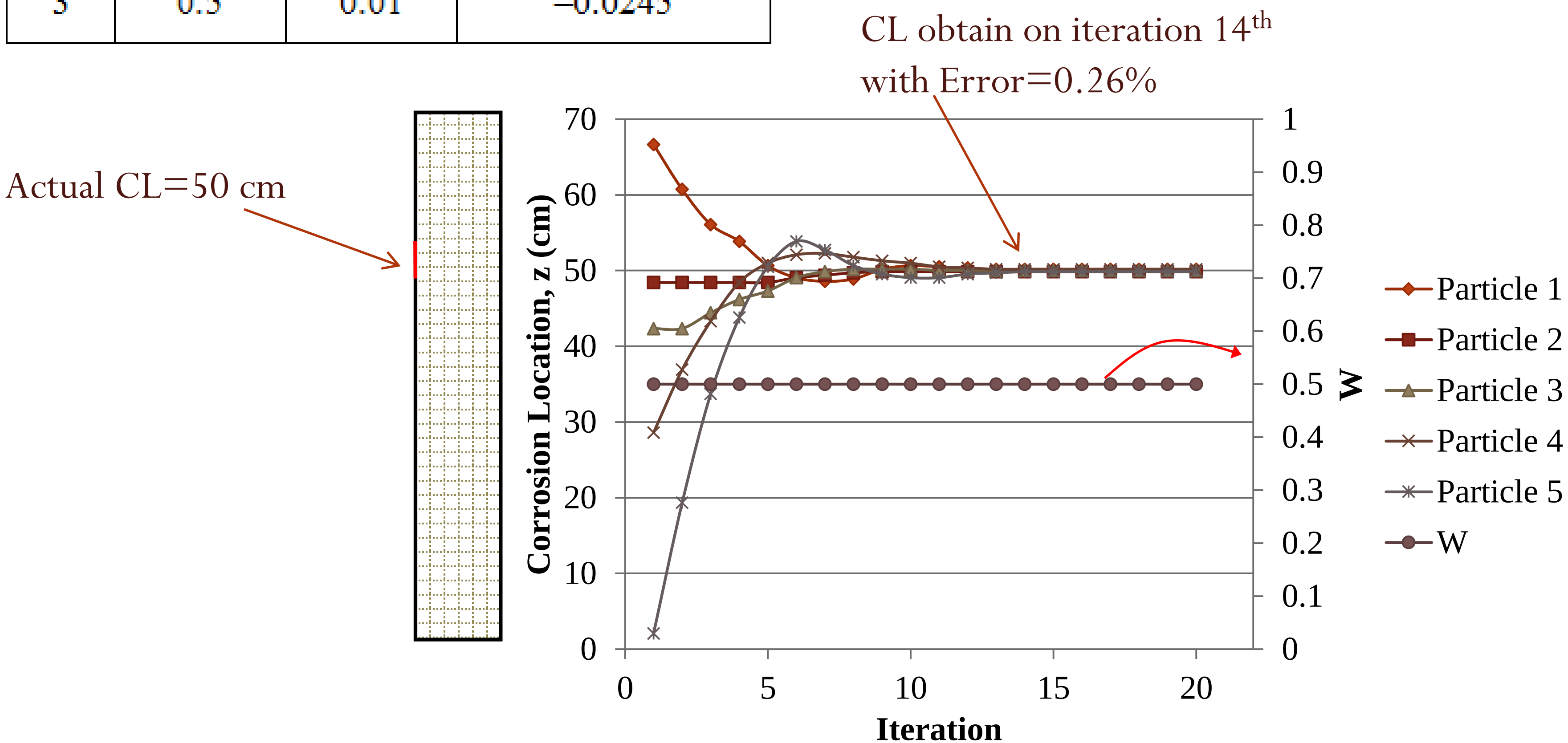
Generated from the polarization curves

BEM simulation result with corrosion location at x=50 cm and size 2 cm

The values of W_{up} and W_{low} for the simulation

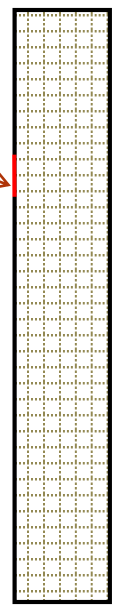
No.	W_{up}	W_{low}	Gradient of W during iteration
1	0.5	0.5	0
2	0.5	0.2	–0.015
3	0.5	0.01	–0.0245

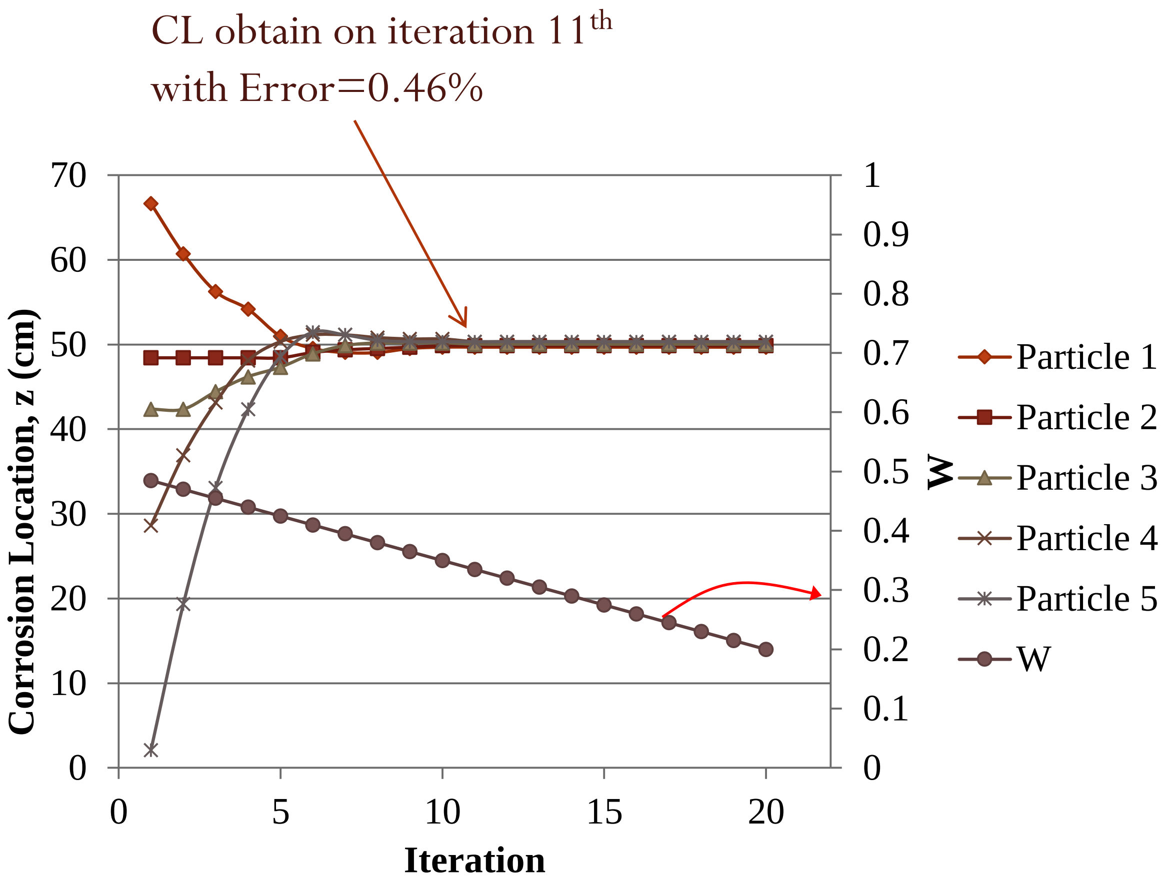
Simulation no. 1



The particle movement and the value of W during iteration for $W_{up} = 0.5$ and $W_{low} = 0.5$

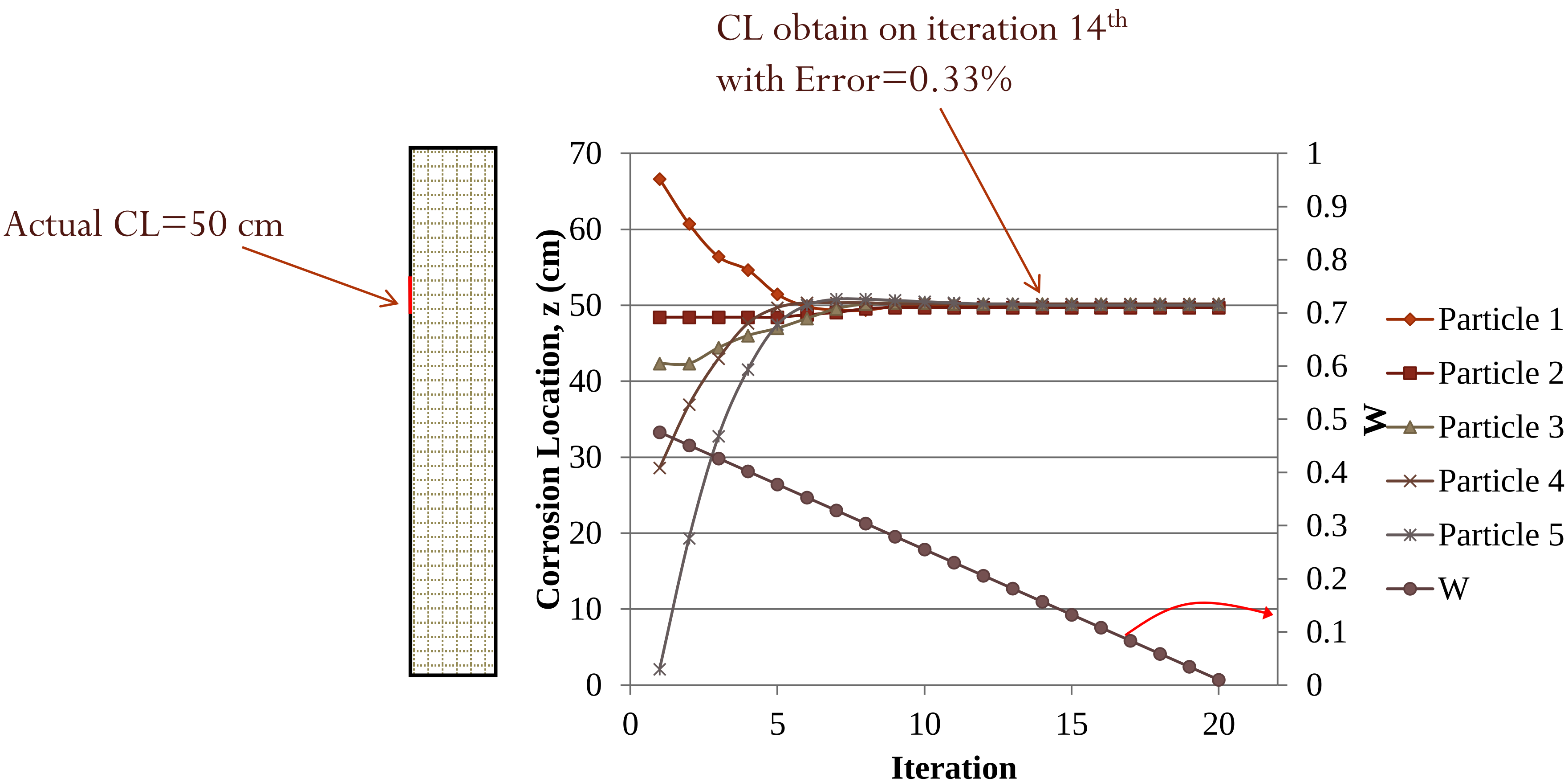
Simulation No. 2





The movement of particles and value of W during iteration for $W_{up} = 0.5$ and $W_{low} = 0.2$

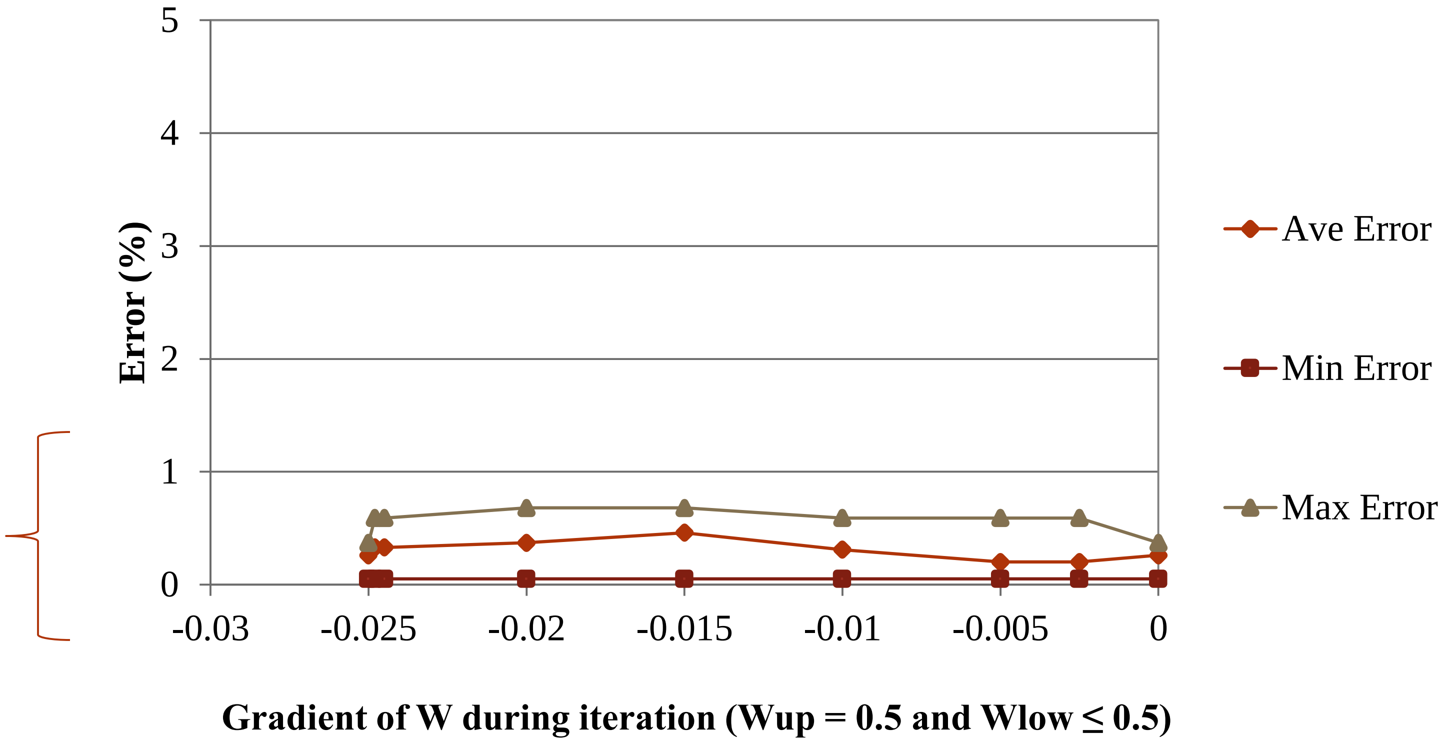
Simulation No. 3



The movement of particles and value of W during iteration for $W_{up} = 0.5$ and $W_{low} = 0.01$

Resume of all simulation

Less than 5%



The error in detecting actual corrosion for $W_{up} = 0.5$ and $W_{low} \leq 0.5$

Conclusions

- The effect of inconstant W on BEIA when detecting rebar corrosion in concrete was explored
- the inconstant W with $W_{up} = 0.5$ and $W_{low} \leq 0.5$ did not influence the performance of the BEIA in detecting rebar corrosion
- The error with respect to the actual location of corrosion (inconstant W with $W_{up} = 0.5$ and $W_{low} \leq 0.5$) was less than 5%

Further study:

important to conduct further research to study the effect of $W_{up} > 0.5$ for inconstant W

THANK YOU