

# Effect of Salt contamination on the long term Compressive Strength and Piezoresistive sensitivity of Smart Cement

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**Abstract:** The long term (28 days) electrical and piezoresistive properties for Smart Cement (water to cement ratio 0.4) prepared in saline water (salinity 35gm/L) are studied. Saline water decreases the initial, minimum, 1 day and 28 day resistivity of smart cement and also affected the piezoresistive sensitivity of smart cement grout. With salt contaminated water, the compressive strength for 1 day and 28 days of curing increased by about 30% and 9% respectively.

## 1. Introduction:

When there is a flow of cement slurry in the annular of the well drilled in a saline zone, dissolution of the salts present in the rock by cement paste can occur, changing its physical properties among other effects, such as an acceleration or reduction of cement hydration (Lago, F. R., Dweck, J., 2018). High amounts of salts have been used on purpose in well cementing since early 1950 to mitigate dissolution in massive salt environments (cementing practice in Gulf of Mexico - GOM) that might otherwise jeopardize the cement sheath to formation bonding (Hunter and Tahmourpour, 2009). Salinity has the capability to damage the structure externally and internally as well as it also can break the strong chemical structures of binding materials (Paul, B. K., Howlader, M. K., 2016). Hence there is a need to describe the behavior of salt contaminated smart cement.

## 2. Objectives:

The objective was to monitor and understand the electrical and piezoresistive properties of salt contaminated smart cement in slurry and hardened state and to differentiate them with that of standard smart cement grout.

## 3. Materials and Method:

In this study, smart cement samples were prepared with water to cement ratio of 0.4, with 0.05% of conductive filler. Samples were prepared by mixing conductive filler in saline water (35gm/L) followed by cement being added in the saline solution by hand mixing. Specimens were prepared in cylindrical molds of height 4 inches in height and 2 inches in diameter. Wires were inserted in these molds about 1 inch apart. To determine the electrical resistivity, 2 probe method was adopted and two wires were used to measure the Resistance by an AC measuring device. Resistivity ( $\rho$ ) is defined as  $RA / L$ . Initial Resistivity ( $\rho_0$ ) was measured in slurry state by a conductivity probe, A/L ratio was then determined. This A/L was used to determine resistivity of smart cement grout in hardened state.

## 4. Results and Discussion:

Effect of salt contamination on the electrical and piezoresistive properties of smart cement grout were monitored and compared with standard smart cement grout.

### 4.1 Resistivity:

It was observed that salt contamination reduces the initial resistivity to  $0.487\Omega \text{ m}$  from  $0.96 \Omega \text{ m}$  for standard smart cement grout thereby also accelerating the hydration time from 140 mins to 80mins. After 1 day and 28 days of curing, resistivity of smart cement (SC) grout was  $3.34\Omega \text{ m}$  and  $15.64\Omega \text{ m}$  respectively,

which decreased to 1.05  $\Omega$  m and 2.36  $\Omega$  m for salt contaminated smart cement sample. (Fig. 1).

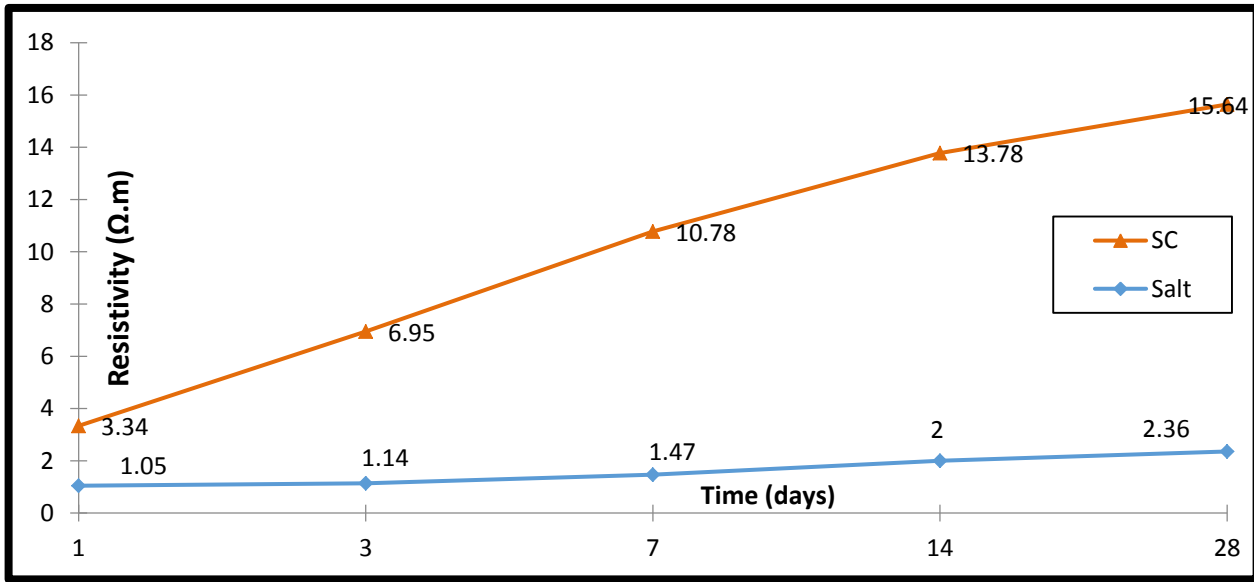


Fig – 1. Resistivity of smart cement with and without salt contamination

**4.2: Compressive strength and Piezoresistivity:**

Piezoresistive response for standard smart cement sample (Fig.2 & 3) at 1 day and 28 days of curing was 212% and 176% whereas salt contamination increased the response to 344% and 301% respectively. Addition of salt also showed similar trend on the compressive strength as it increased to 2250 psi and 4230 psi from 1550 psi and 3550 psi for standard cement grout for 1 day and 28 days of curing respectively.

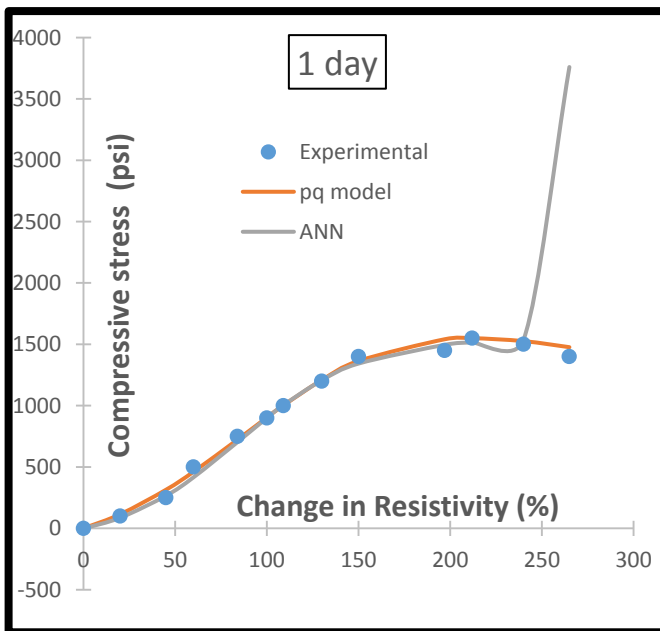


Fig – 2. Compressive strength vs piezoresistivity of standard smart cement at 1 day of curing

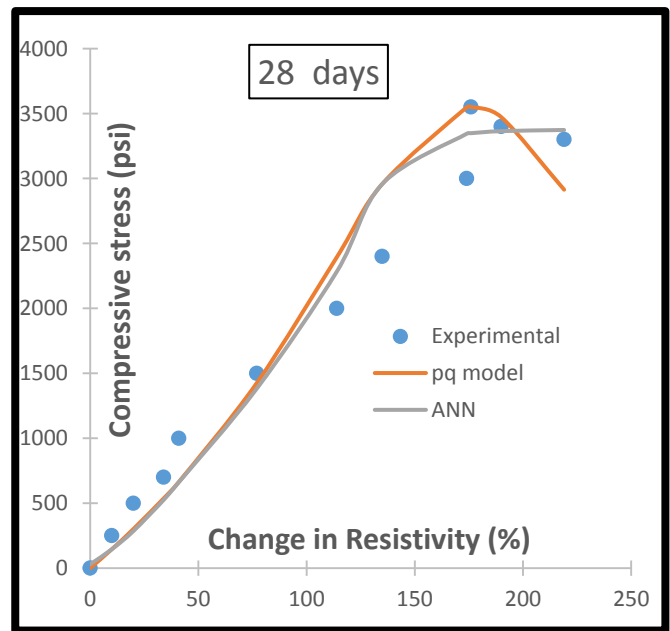
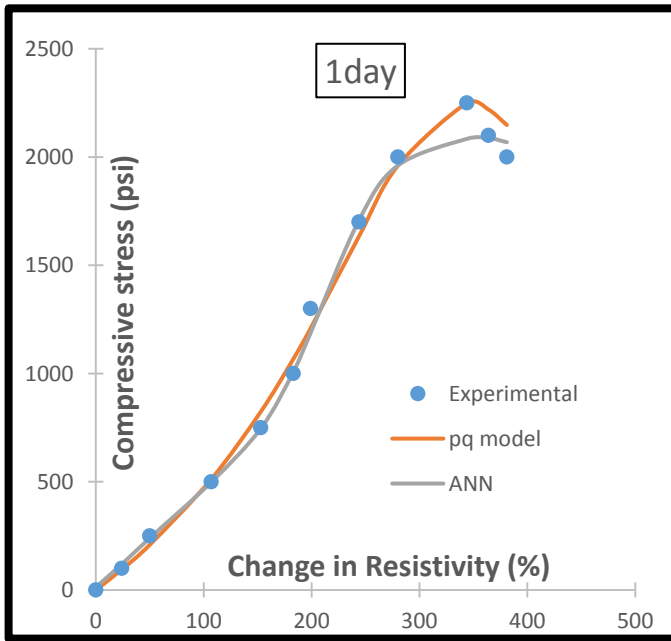
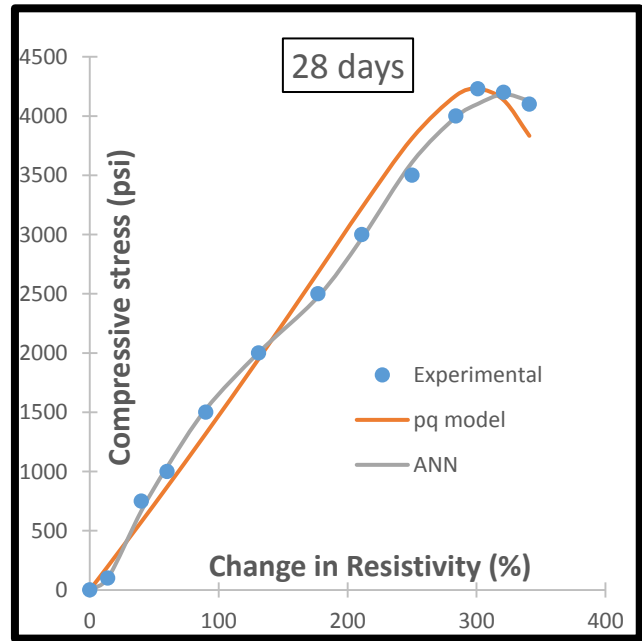


Fig – 3. Compressive strength vs piezoresistivity of standard cement at 28 days of curing



**Fig – 4. Compressive strength vs piezoresistivity of smart cement with salt contamination at 1 day of curing**



**Fig – 5. Compressive strength vs piezoresistivity of smart cement with salt contamination at 28 days of curing**

Above four figures represent the piezoresistive behavior of smart cement sample (with and without salt contamination) at 1 and 28 days of curing. The experimental data have been plotted with Vipulanandan p-q model and also compared with Artificial Neural Networks (ANN). Various orders of hidden layers were used for analysis by Artificial Intelligence. It was found by 3<sup>rd</sup> order of ANN provided the most accurate prediction.

	Days of curing	Vipulanandan p-q model				ANN
		p2	q2	R <sup>2</sup>	RMSE	RMSE
<b>SMART CEMENT</b>	<b>1</b>	0.38	0.51	0.99	21.88	71.42
	<b>28</b>	0.16	0.62	0.99	17.24	17.2
<b>SALT CONTAMINATION</b>	<b>1</b>	0.13	0.86	0.99	8.11	14.14
	<b>28</b>	0.22	0.57	0.98	23.45	13.67

**5. Conclusion:**

1. Salt contamination reduces the initial and minimum resistivity by about 49% each. Also, the 24hr resistivity increased by 68% followed by 85% for 28 days of curing.
2. The piezoresistive behavior and compressive strength of the smart cement were also affected. The piezoresistivity of smart cement with salt contamination increased by 38% and 41% along with the increase in compressive strength by 31% and 16% for 1 day and 28 days of curing respectively as compared to those of standard smart cement grout.

**6. Acknowledgements:**

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**7. References:**

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