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Blast response of full-size concrete walls with chemically reactive enamel (CRE)-coated steel reinforcement

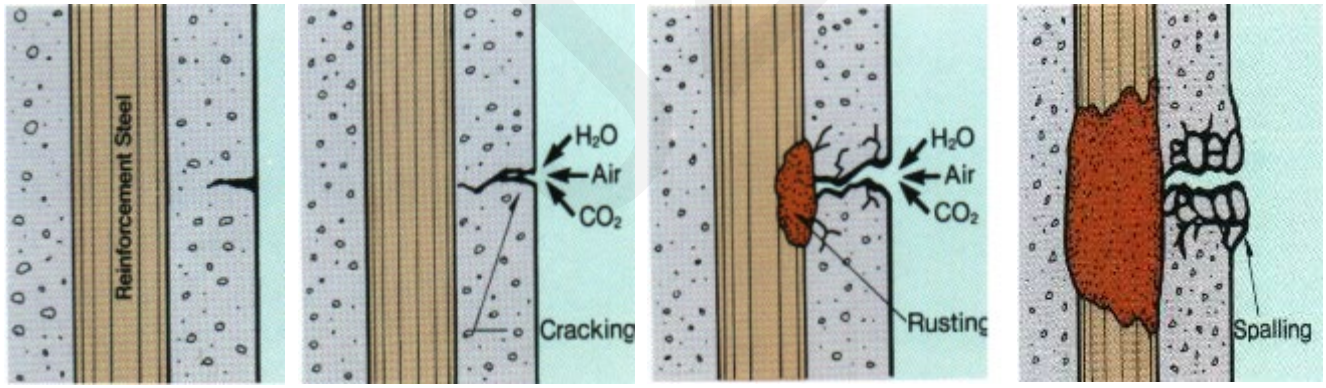
Key words: CRE coating, blast loading, crack pattern, bond strength, finite element model

BACKGROUND

- The corrosion of steel bars in reinforced concrete (RC) structures has been a main concern in civil engineering for many decades. Today, the long-lasting concern becomes ever more serious as more civil infrastructure has been built in modern society.

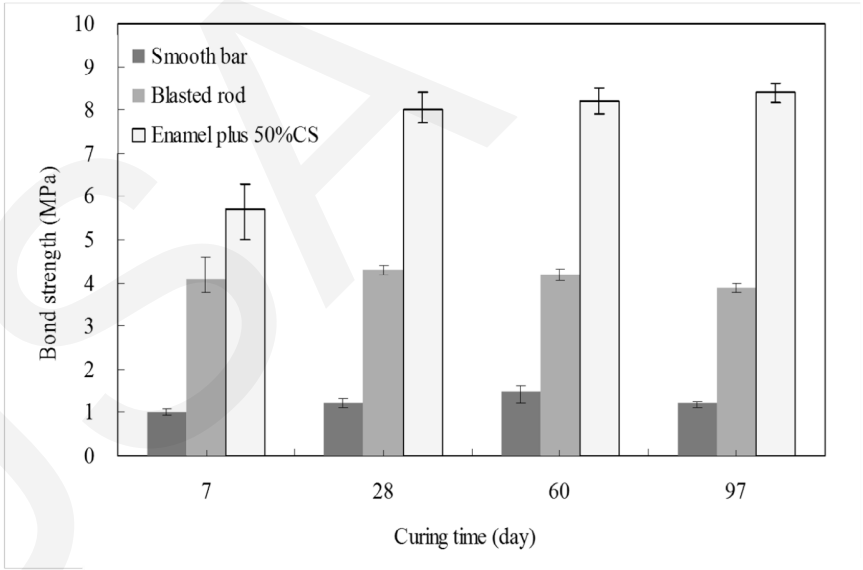
- Corrosion-resistant coating has been regarded as one of the direct, efficient and cost-effective ways to prevent or delay the corrosion process of rebar in concrete structures.

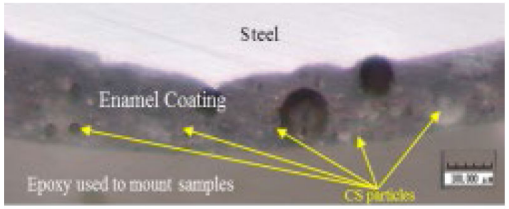
- Epoxy coating could accelerate the corrosion process of steel bar since moisture can be trapped between the coating and steel bar, while chemically reactive enamel (CRE) coatings have been shown to significantly improve the corrosion resistance of steel bar

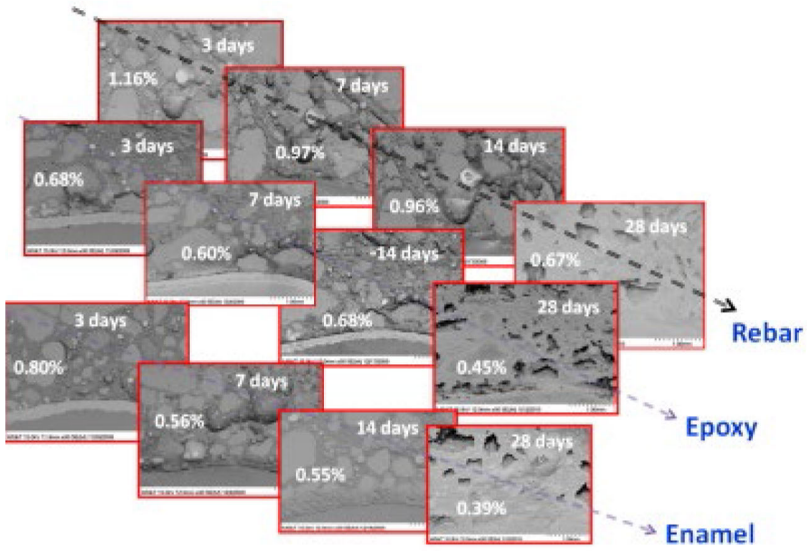


CRE COATING

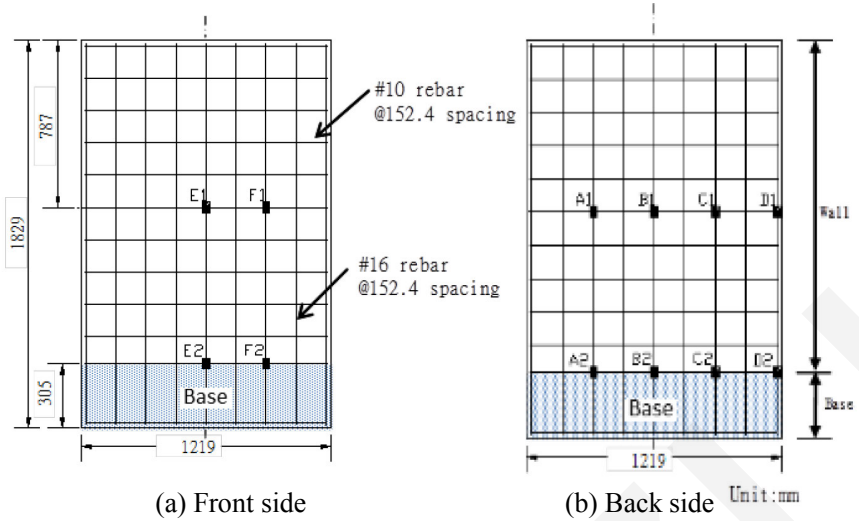
- CRE coating, particularly when mixed with calcium silicate, provided an excellent transition medium between the steel and concrete and minimized the so-called interfacial transition zone in RC structures through chemical reactions with both steel and concrete.
- CRE coatings have been shown to significantly improve the corrosion resistance of steel bar
- In the present work, we aimed (a) to demonstrate the effectiveness of CRE coating in improving the serviceability and safety of RC barrier walls under blast loading, and (b) to verify the increase in bond strength of CRE-coated steel bar in concrete in real-world wall structures.





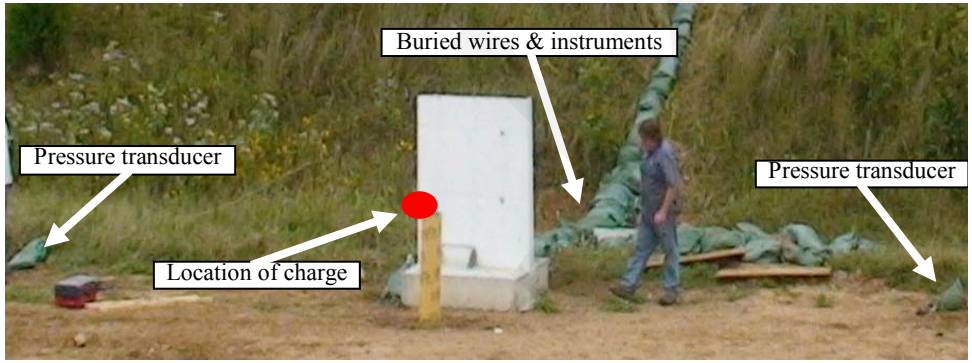


BLAST TEST

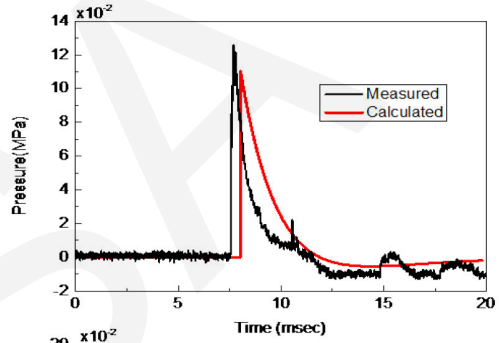


(a) Front side (b) Back side

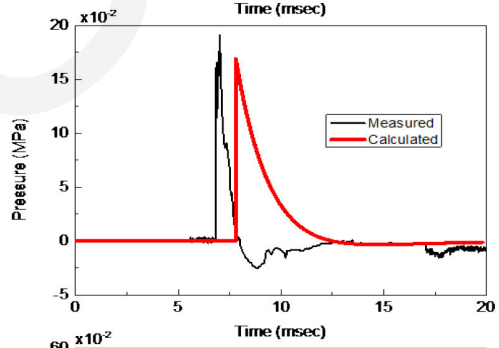
Barrier wall details, strain gauge locations and designations



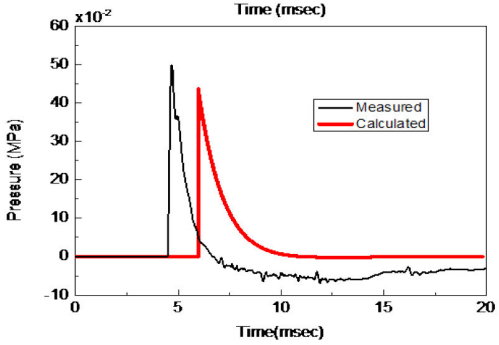
Test site



(a) 1.82 kg TNT



(b) 4.54 kg TNT



(c) 13.6 kg TNT

Pressure time histories at the location of a pressure transducer

TEST RESULTS

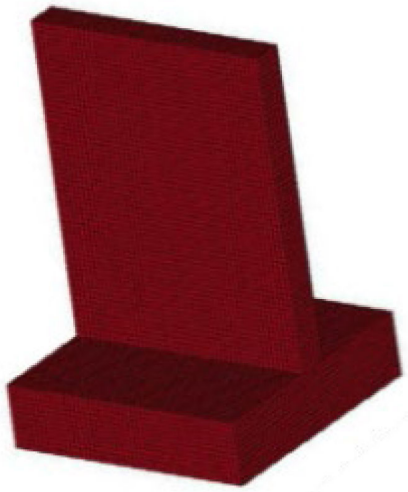
(a) Front faces

(b) Back faces

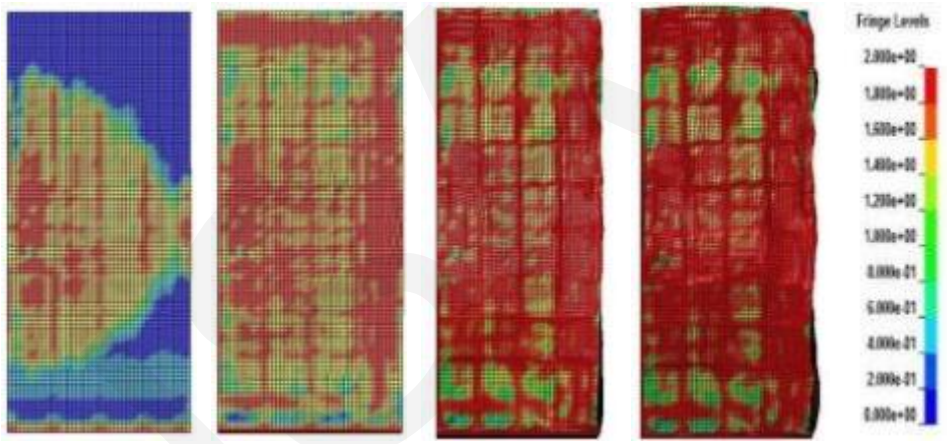
Crack patterns and comparisons of two barrier walls after the first three tests

Damaged walls after 20.4 kg TNT equivalent blast tests

NUMERICAL ANALYSIS RESULTS

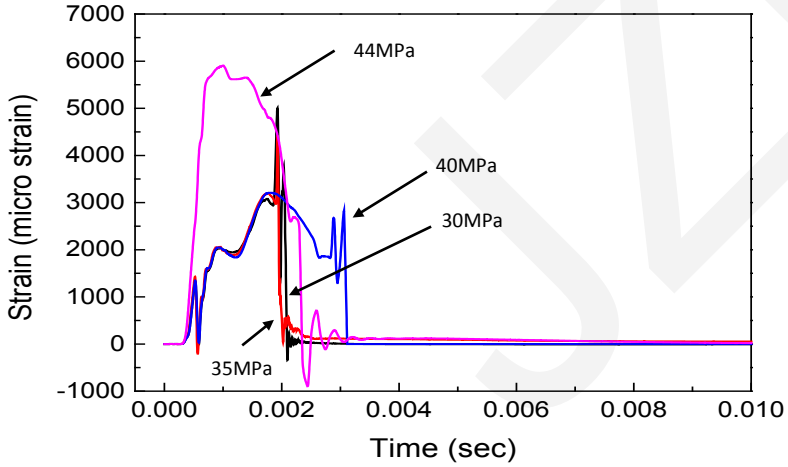


Meshed finite element model of barrier wall

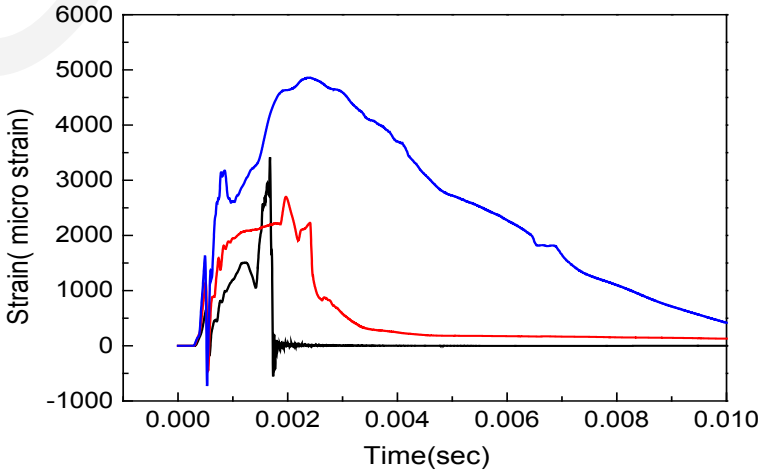


(a) 0.51 msec (b) 0.67 msec (c) 1.99 msec (d) 4.50 msec

Effective plastic strain distribution of the concrete wall with CRE-coated rebar under a charge of 13.6 kg



Influence of interface material strength on the rebar strain time history at location B1 under a charge of 13.6 kg



Influence of rebar size on the steel strain time histories at location B1 of the wall with CRE-coated rebar under a charge of 13.6 kg

RESULTS AND CONLUSIONS

- **The crack patterns visually observed on the surfaces of the two walls under a 1.82-kg, 4.54-kg, and finally 13.6-kg charge, clearly indicated that CRE coating firmly joined concrete to its nearby steel bar due to superior mechanical and chemical bonds of the mixed enamel with concrete, resulting in fewer rebar-concrete slippages and fewer cracks on the face of the wall. Therefore, the use of CRE coating in RC walls can enhance the serviceability of barrier walls under blast loads.**
- **The strain measurements in steel rebar under 1.82-kg, and 13.6-kg charges verified that more stresses were transferred from concrete to the CRE-coated rebar due to increased bond strengths between the CRE-coated rebar and concrete. Comparison of the ultimate failure modes of the two walls under a 20.4-kg charge further indicated the improved rebar-concrete bonding. Therefore, the use of CRE coating can improve the integrity and safety of barrier walls.**
- **The finite element model of RC barrier walls under a close-in charge was calibrated with the measured pressure in air and the measured strains in rebar. The effect of CRE coating on the behavior of walls can be simulated by the introduction of a re-bar-concrete interface layer with compressive strengths of 35.0 MPa and 44.0 MPa for uncoated and CRE-coated rebar, respectively. The validated model can predict the concrete surface strain distribution with concentration around the rebar grid, and was in good agreement with the visual-ly-observed crack pattern on the surface of walls. A flexible design of barrier walls with small rebar is desirable for the mitigation of blast-induced damage or concrete cracks.**