

Meso-scale corrosion expansion cracking of ribbed reinforced concrete based on a 3D random aggregate model

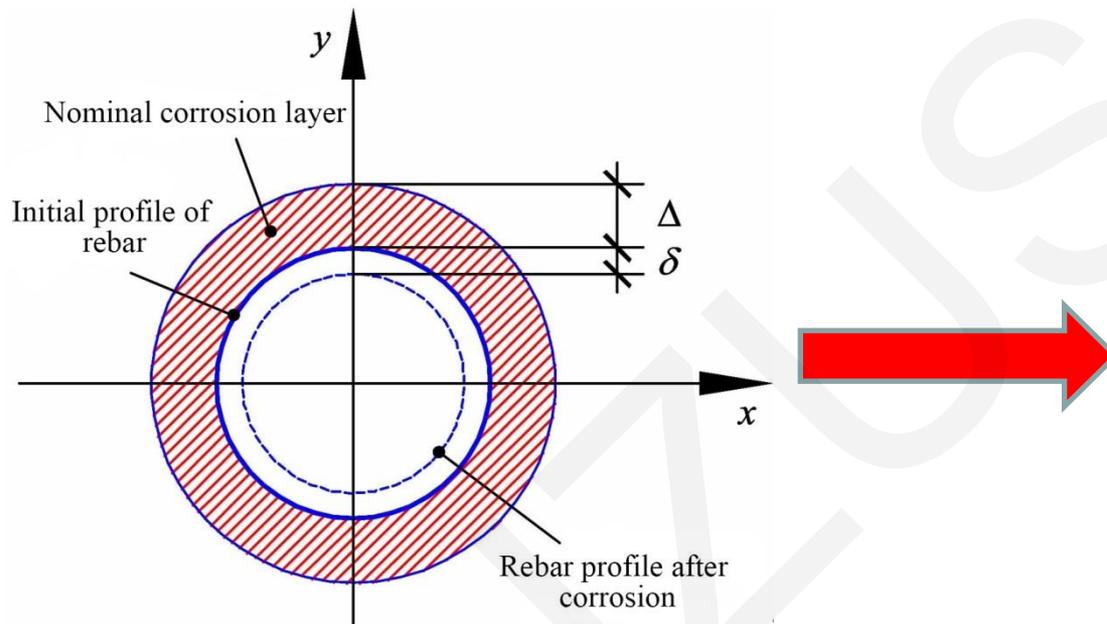
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Research Purpose

Reinforced concrete structures will naturally rust and expand in volume causing structural cracking. The purpose of this paper is to discover the law of corrosion expansion in order to improve the durability of the structure.



Section of the corroded rebar



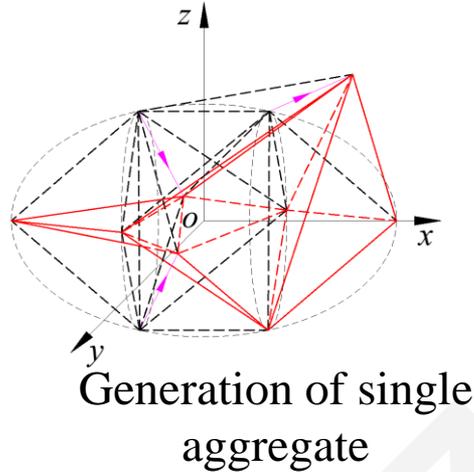
Scenario of a Single Rebar



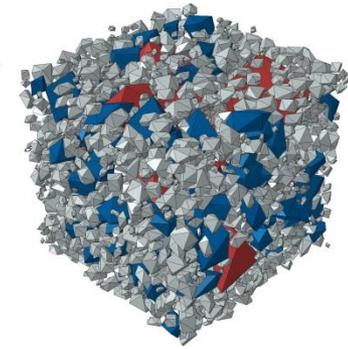
Scenario of Multiple Rebars

Research Method

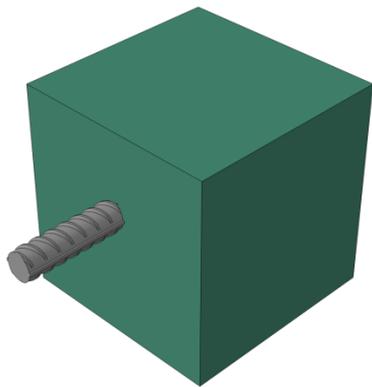
This paper established a 3D Meso-scale model based on the secondary development of ABAQUS to analyze the crack pattern and the number of destroyed element of the structure and so on under different working conditions of single and multiple reinforcement cases.



Generation and placement
of aggregate inventory



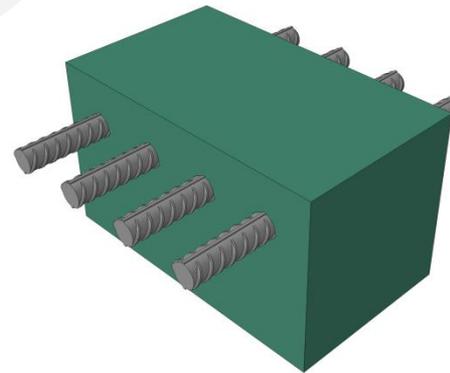
3D Meso-scale model



Working conditions

- Concrete thickness;
- Arrangement of rebars

Finite element model



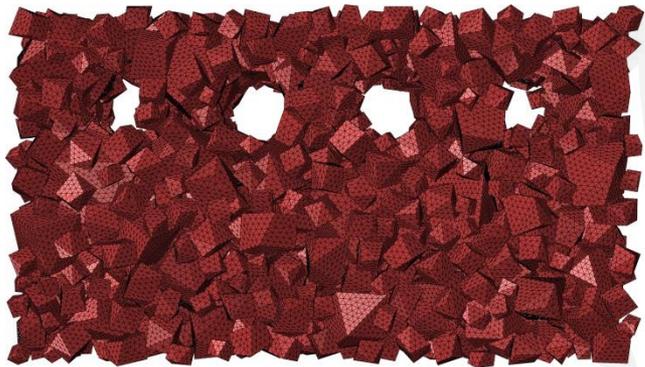
Working conditions

- Rebar spacing

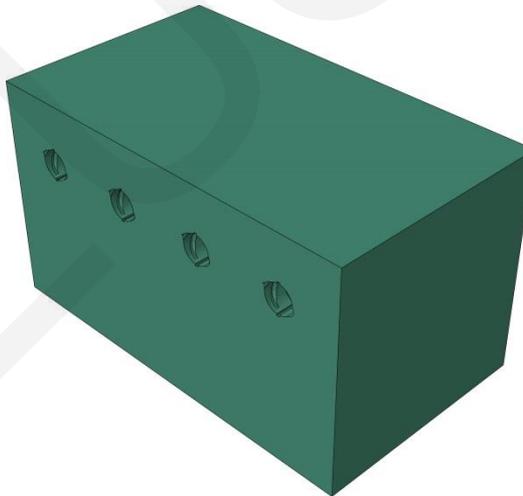
Finite element model

The innovation points

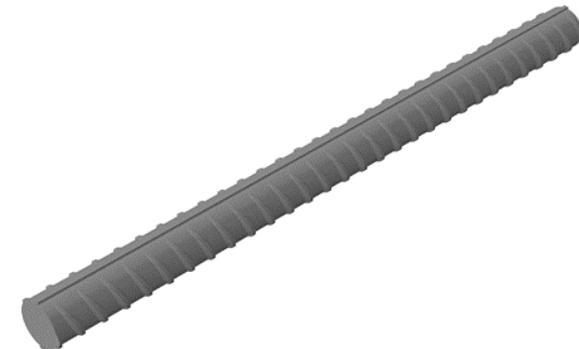
- A 3D Meso-scale model was established based on ABAQUS secondary development;
- The ribbed steel bar was used to replace the round steel bar in traditional numerical simulation;
- The failure of reinforced concrete Interface Transition Zone(ITZ) was considered.



ITZ



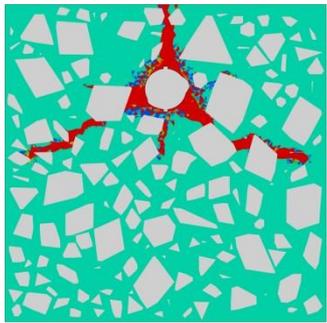
Mortar



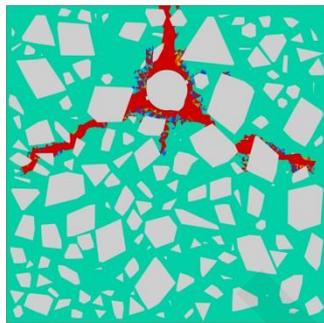
Ribbed rebar

Conclusions

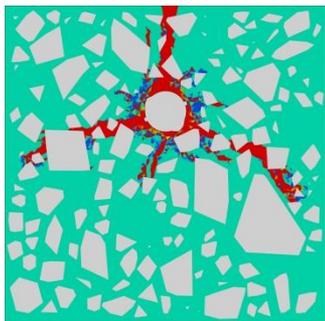
- ◆ The overall pattern of cracks caused by corrosion expansion cracking of rebars was cross-shaped, with a slightly shorter lower limb.



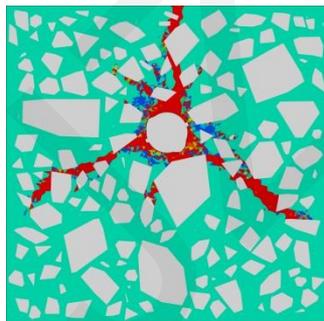
(a) 20mm



(b) 30mm

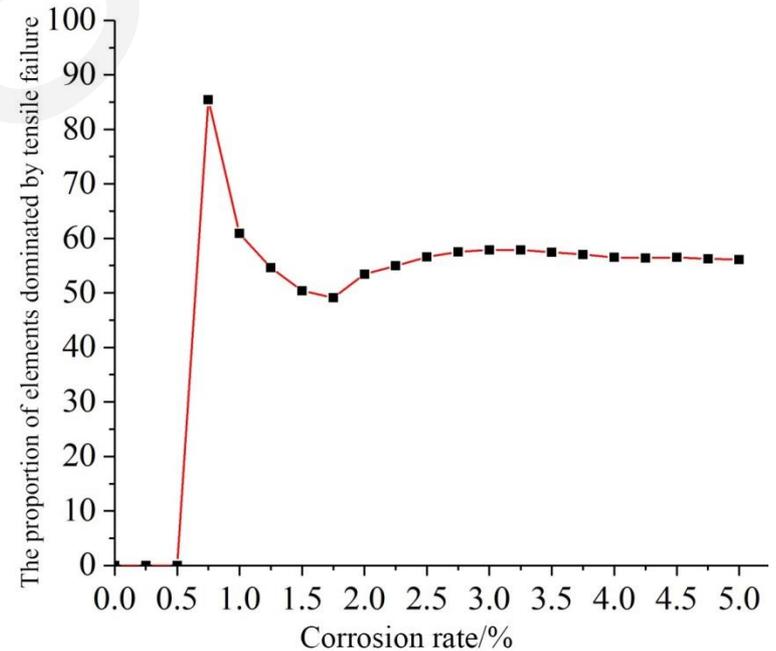


(c) 40mm



(d) 50mm

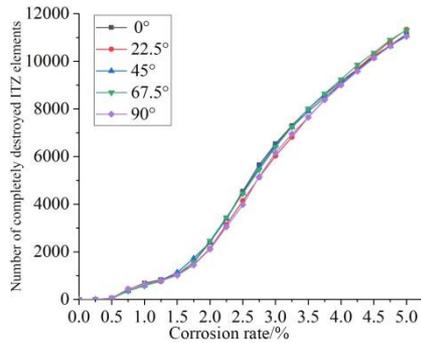
- ◆ No ITZ elements were completely destroyed when the corrosion rate was low. with the further increase of the corrosion rate, the proportion of ITZ elements dominated by tensile failure increase first, and then falls, and then rises to stabilize.



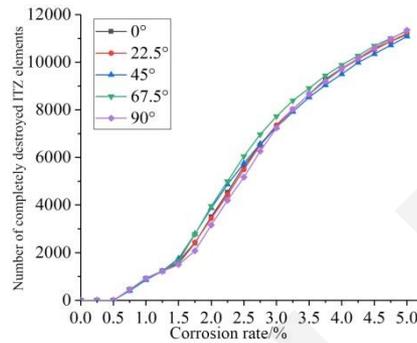
Conclusions

- ◆ The cross-section arrangement of rebars had little influence on the ITZ failure mode.

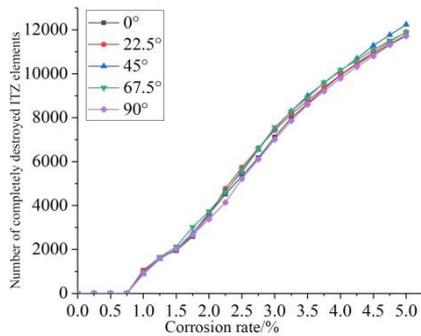
- ◆ With the increasing of the cover thickness, the corrosion rate for ITZ elements that was completely destroyed for the first time



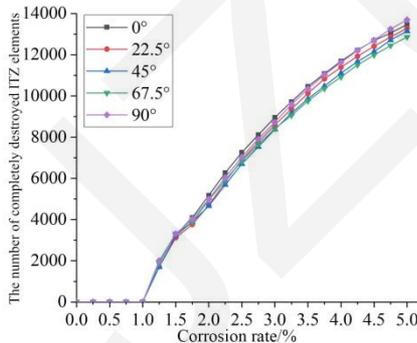
(a) 20mm



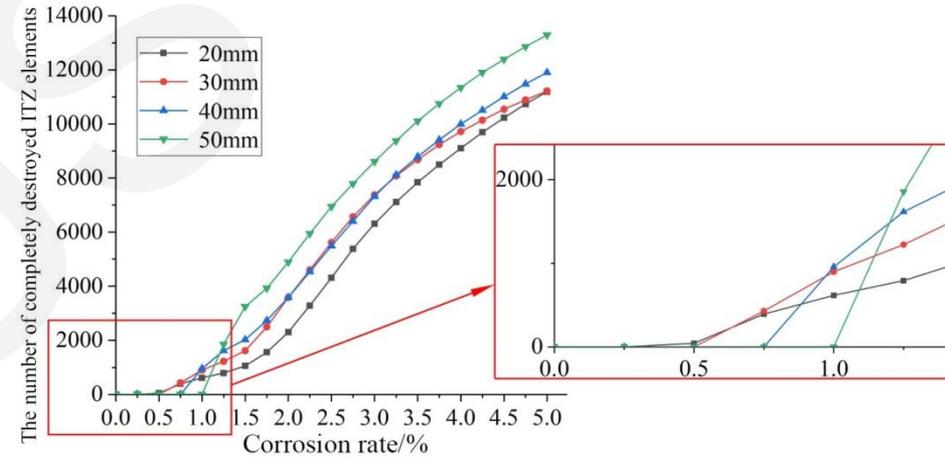
(b) 30mm



(c) 40mm

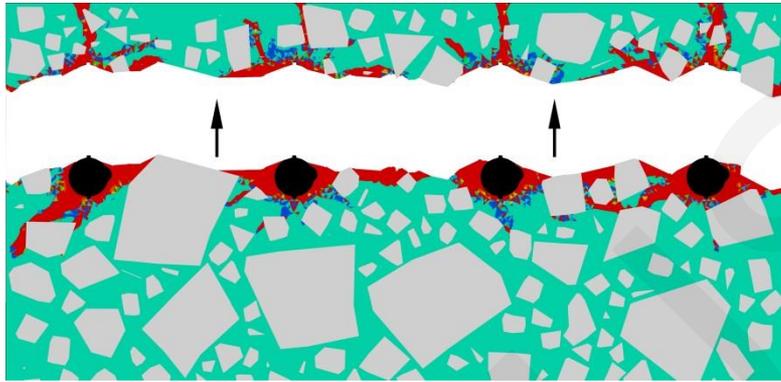


(d) 50mm

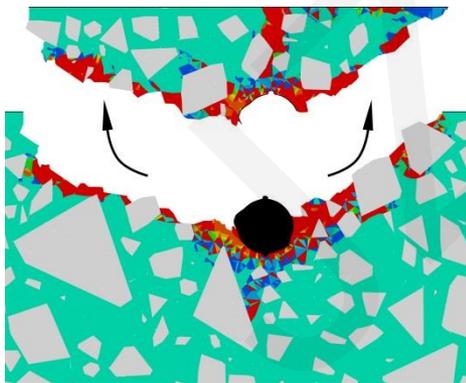


Conclusions

- ◆ In the case of multiple rebars, the concrete cover will be spalled when the spacing between the steel bars is small, and wedge-shaped peeling will occur when the spacing is large.



(a) Spalling



(b) Wedge-shaped peeling