Fracture Simulation of Concrete with ASR and DEF Expansion by RBSM

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ABSTRACT

In this investigation, mechanical behaviors affected by two main expansion causes: Alkali-silica reaction (ASR) and Delayed ettringite formation (DEF), are predicted by the three-dimensional Rigid Body Spring Model (RBSM). By dissection concrete into 2~3mm randomized polynomial elements and analysis the forces between elements through spring connecting them, RBSM is specially a good solution for fracture analyses. ASR and DEF simulation is carried out for both separative and combinative cases. For DEF, initial expansion strain is applied among mortar elements, to reflect the expansion caused by high temperature during curing, which is more concentrated in the inner part where mortar elements experienced higher curing temperature. While in the case of ASR, the expansion strain is applied at the mortar-aggregate interfaces, to reflect the alkali silicate gel formation in and around the aggregates. This is an exclusive approach to discuss the combination of the effect of these two common causes of concrete expansion in long-term, which is difficult to be analyzed using traditional experiment due to its long experiment term required and complexity of quantitatively determinate the contribution of each expansion cause.

In the simulation, cracking patterns due to ASR and DEF are well presented. Especially in DEF case, cracks are more localized with expansion given more concentrated in the inner part. Crack patterns caused by combinations of ASR and DEF are also well reproduced by the simulations. Also, residual compressive strength after expansion, which is critical to quantitively evaluate remain structural performances, is also investigated by fracture simulation under loadings.

REFERENCES

[1] Eddy, L., Awasthi, A., Matsumoto, K., Nagai, K., and Asamoto, S., 2016. Mesoscopic Analysis of Different Expansion Causes in Concrete by 3D Rigid Body Spring Model. *15th Int'l Symposium on New Technologies for Urban Safety of Mega Cities in Asia*.