Response Statement to Referee's Comments (RC2)

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The authors thank the reviewer for the valuable comments. The manuscript has been revised by carefully considering all the comments. The changes are highlighted in the marked copy, and detailed responses to the reviewer's comments are provided below.

Comment #RC2:

please better clarify how saturation can remain constant upon loading and compaction.

why wasn't the water content considered instead?

Response:

We thank the reviewer for this insightful comment. We agree that, in deforming porous media, the physically conserved quantity is the volumetric water content $\theta = nS_r$, and that prescribing a constant degree of saturation without clarification may appear inconsistent with mass conservation.

In the present work, drained loading conditions are assumed, such that the reduction in pore volume during consolidation is primarily accommodated by outward Darcy drainage through the permeable boundaries. Under these conditions, the volumetric water content is not prescribed as constant but is allowed to evolve implicitly through the liquid-phase mass balance and boundary fluxes. For near-saturated geomaterials, where gas connectivity remains limited and no significant desaturation occurs, the degree of saturation may therefore be treated as approximately constant without violating mass conservation.

This modelling assumption and its physical basis have now been explicitly clarified in the manuscript. We further note that this formulation becomes invalid when drainage is impeded or when significant unsaturated flow develops, in which case the degree of saturation (or volumetric water content) must be treated as an independent state variable within a fully coupled multiphase framework.

[Added new content:] *The porous medium is assumed to remain nearly saturated. The liquid phase forms a continuous network and controls flow, while the gas phase is idealised as isolated, immobile bubbles that do not* *participate in advection. Hence, the degree of saturation S_r is prescribed as a constant rather than solved as a state variable, leading to a single-phase liquid formulation in which residual gas influences the system only through the effective compressibility of the pore fluid–solid skeleton. This treatment is consistent with mass conservation under drained conditions, whereby the decrease in pore volume during consolidation is accommodated by outward Darcy drainage, so that the volumetric water content $\theta = nS_r$ evolves implicitly through the liquid-phase mass balance while S_r is treated as approximately constant. This approximation is suitable for wet, low-permeability geomaterials where S_r typically exceeds 0.8–0.9 and varies slowly relative to the consolidation timescale, such that deformation-driven transport dominates over transient unsaturated flow, as in compacted clay barriers and landfill liners under quasi-steady infiltration.*

[Line 258–259]