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A Review of Strain-Based Permeability Approach for Leakage Rate Estimation

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1. Introduction

In the event of a failure of the containment buildings, it is crucial to assess the amount of radiation that could potentially leak into the environment. The available leakage rate estimation formulae use crack geometry to predict leakage rate. However, cracks develop irregularly and it is difficult to measure or predict the actual crack geometry. Therefore, this study reviews an alternative method to predict the leakage rate by calculating the permeability based on the strain.

2. Literature Review

In this section, the existing literature on estimating leakage rate based on permeability is reviewed. Many studies have proposed equations to predict the leakage rate based on the geometry of cracks (crack width and crack length). This is usually done by fitting experimental results based on the Poiseuille equation. However, cracks occur randomly and their geometry is difficult to predict. In contrast, there have been some attempts to predict the leakage rate based on strain, which is the global behavior of the structure. One of the older studies that attempted to predict leakage rate based on strain is the experiment by Nagano et al [1]. The authors formulated the leakage rate of reinforced concrete walls with shear cracks in terms of shear stress and shear strain. However, in the study, the leakage rate was fitted directly as the function of strain without any consideration of permeability.

Jason et al. [2] presented a method to predict leakage rates by calculating the hydro-thermo-mechanical response a representative volume of containment buildings under internal pressure. For the mechanical problem, scalar damage model by Mazars [3] was used for concrete. Next, the permeability laws by Bary [4], Picandet et al. [5], and Souley [6] were applied to calculate the permeability of concrete from the damage. Once the permeability of the concrete is calculated, the leakage rate is estimated based on Darcy's law. The above framework was applied to the finite element analysis. The overall procedure can be represented as shown in Figure 1.

Jason and Masson [7] developed Jason et al. [2] research. The authors noticed it is difficult to accurately predict where the most damage had occurred. To overcome this difficulty, the existing prediction methods based on the individual crack geometry were used in areas of high damage.

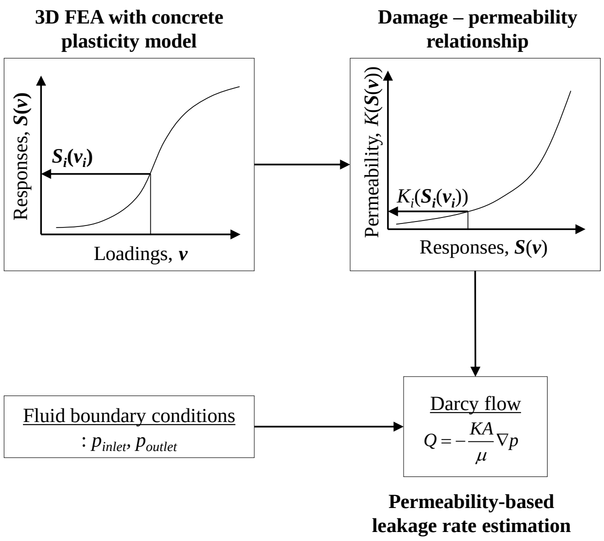

Fig. 1. Scheme of strain-based permeability approach

3. Discussion

The damage-permeability relationships in the framework describe above is considered to need improvement for more accurate prediction. The permeability law was derived from the unreinforced concrete experiments, but it is necessary to verify its applicability to the reinforced concrete.

4. Conclusions

In this study, existing research on predicting leakage rates in containment buildings with a strain-based permeability approach was reviewed. Unlike the existing method that mainly predicts leakage rate based on discrete cracks, the strain-based permeability approach is combined with Darcy's law to predict leakage rate. However, the permeability law is mostly based on experiments on unreinforced concrete, so it is necessary to verify whether it can be applied to containment buildings that are reinforced concrete structures.

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