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PREFACE

This research was carried out within the Geotechnical and Material Engineering group of the LTDS (Laboratory of Tribology and Dynamics of System) – *Geomatériaux du LTDS* of the Ecole Centrale de Lyon (ECL) in partnership with EDF (Energie de France) and Universitas Indonesia (Depok - Indonesia).

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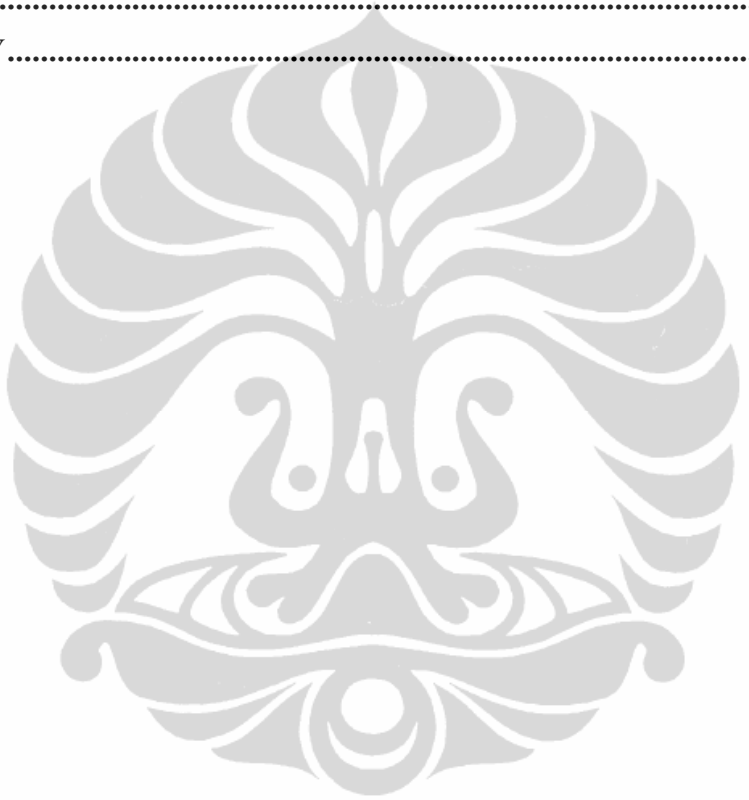

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ABSTRACT

Internal Erosion initiated by water movement along channels called tunnel erosion, often crack or defect the dam's structure. It is one of the main causes of water structure's (dams, dikes, etc.) collapse. This phenomenon can be divided into 3 phases, tunnelling, collapse, and the opening of the channel inside the dam [1]:

- "Tunnelling" transport large quantities of particles due to the hydraulic gradient. It's happen fast in a preferential path especially in some point of dam structure's weaknesses.
- The gradual collapse of the roof of tunnel erosion allows the expansion of the channel.
- The opening of the channel is started after the collapse of the channel by tunnel erosion.

Research has been done to explain the phenomenon of collapse, but there are still questions, including the formulation, phase, and form of the rupture. Moreover, the equation used is not always adapted to the various cases of the soil. Research by Hunt and Hanson showed the different phases of a dam collapse with a rate of expansion of a hole driven only by the constraint of shearing.

Through this numerical study, we find that their hypothesis is not correct, because there are other parameters that affect this phenomenon and also the effect of traction force. The study is simplified by modelling an earthen dam with a given cavity; where the undrained cohesion is controlled to see at which value of cohesion the fracture achieved. This simplification is the opposite in the real case, where the cohesion is fixed but the cavity expands. We find that the collapse of the earthen dam because of the tunnel erosion occurs in two stages: the arching effect in the channel across the dam that makes vertical sag then collapse, and the expansion of the channel which is inclined more like a slope. The high of the dam and the form of the "tunnel" cavity also influenced the failure mode.

Keyword: Internal Erosion, Collapse, Numerical Study, Tunnelling.

Résumé

L'érosion interne dans un conduit dit « renard », résulte de l'infiltration d'eau souvent une fissure où un défaut à travers le corps du barrage. Elle est l'une des causes principales de ruptures hydrauliques (barrages, digues, etc.). Ce phénomène peut être décomposé en 3 phases, la phase de renard, l'effondrement, et la phase de brèche [1] :

- La phase de renard est à l'origine du transport des grandes quantités de particules à cause de la présence d'un gradient hydraulique. Celle-ci se fait rapidement dans un cheminement préférentiel le long duquel sont répartis un certain nombre des points faibles.
- L'effondrement progressif du toit du renard permet l'agrandissement du conduit.
- La phase de brèche est atteinte lors de la rupture totale du renard.

Des recherches ont été faites pour expliquer le phénomène d'effondrement, mais il reste encore des interrogations, notamment sur la forme de la rupture. Par exemple, l'équation utilisée n'est pas toujours adaptée aux différents cas du sol. Le travail de *Hunt et Hanson* a montré les différentes phases de rupture d'un barrage dont le taux d'élargissement d'une brèche est piloté uniquement par la contrainte de cisaillement.

Par cette étude numérique, nous trouvons que son hypothèse n'est pas correcte, auto il y a d'autres paramètres qui jouent sur ce phénomène et notamment la résistance à la traction du sol. L'étude réalisée est simplifiée par un barrage en terre avec une cavité donnée, où sa cohésion non drainée est diminuée pour voir à quelle valeur de cohésion on atteint la rupture. Ce qui est le contraire du cas réel où la cohésion est fixe mais la cavité s'agrandit. Nous trouvons que l'effondrement du barrage en terre à cause du renard se produit en deux temps : l'effet de voûte dans un conduit qui fait une affaissement vertical puis l'agrandissement de la brèche par formation d'un talus. La hauteur du barrage et la cohésion du sol influencent aussi le mode de rupture.

Mot Clé: Etude Numérique, L'érosion interne, L'effondrement, Renard.