STATIC AND SEISMIC INVESTIGATION OF RETAINING WALLS USING DISCRETE AND CONTINUUM APPROACH

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by

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submitted in fulfillment of the requirements of degree of

DOCTOR OF PHILOSOPHY

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Dedicated to my family

For their endless love, support, and encouragement

CERTIFICATE

This is to certify that the thesis entitled "**STATIC AND SEISMIC INVESTIGATION OF RETAINING WALLS USING DISCRETE AND CONTINUUM APPROACH**" submitted by **Ms. Prerna Singh (2017CEZ8532)** to the **Indian Institute of Technology (IIT) Delhi** for the award of the degree of **DOCTOR OF PHILOSOPHY** is a record of the student's own work carried out under our supervision and guidance. Her research work has reached the requisite standard as demonstrated by excellent research publications in journals and conferences.

To the best of our knowledge and belief, the contents of her research work have not been submitted in full or in part to any other university or institute to confer a degree or diploma.

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ABSTRACT

The present numerical study investigates the discrete and continuum behavior of gravity and cantilever retaining wall soil system under static and seismic loading conditions to get safe and economical design using simple approaches. The microscale-based numerical study of retaining wall supporting cohesionless soil is performed using discrete element method, covering the transition from the initial state to the active state. The earth pressure coefficient from current study is compared with the existing analytical and experimental solutions which concluded that Coulomb and Rankine methods underestimate the active earth pressure. The transition from initial state shows a decrease in average coordination number at wall top indicating the rearrangement and debonding of soil particles and simultaneous decrease in overall density. In addition, the force chain distribution, porosity, particle displacement are also investigated.

Further, continuum-based numerical study is carried out to study the influence of seismic loading on retaining walls using the finite element method (FEM). The influence of input peak ground acceleration (PGA), retaining wall height, relative density of soil, and soil-structure interaction on total active earth thrust (P_{ae}) of gravity and cantilever retaining wall are investigated. Based on the parametric investigation and regression analysis, predictive equations are proposed for the estimation of P_{ae}. In addition, the dynamic behavior in terms of acceleration amplification/deamplification, deformation mechanism, and earth pressure distribution are examined. The discrete analysis provided valuable insights into the particle-level mechanisms underlying the overall behavior of the retaining wall, contributing to a better understanding of its continuum response. This study also contributes to developing equations that are anticipated to provide total active thrust at the initial design stage under comparable work environment.

Keywords: DEM, deformation, earth thrust, earthquake loads, FEM, granular soil, retaining wall

सार

वर्तमान संख्यात्मक अध्ययन सरल तरीकों का उपयोग करके सुरक्षित और किफायती डिजाइन प्राप्त करने के लिए स्थैतिक और भूकंपीय लोडिंग स्थितियों के तहत गुरुत्वाकर्षण और ब्रैकट बनाए रखने वाली दीवार मिट्टी प्रणाली के असतत और सातत्य व्यवहार की जांच करता है। संसंजनहीन मिट्टी को सहारा देने वाली रिटेनिंग दीवार का सूक्ष्म पैमाने पर आधारित संख्यात्मक अध्ययन असतत तत्व विधि का उपयोग करके किया जाता है, जो प्रारंभिक अवस्था से सक्रिय अवस्था में संक्रमण को कवर करता है। वर्तमान अध्ययन से प्राप्त पृथ्वी दबाव गुणांक की तुलना मौजूदा विश्लेषणात्मक और प्रयोगात्मक समाधानों से की गई है, जिसमें निष्कर्ष निकाला गया है कि कूलम्ब और रैंकिन विधियां सक्रिय पृथ्वी दबाव को कम आंकती हैं। प्रारंभिक अवस्था से संक्रमण दीवार के शीर्ष पर औसत समन्वय संख्या में कमी दर्शाता है जो मिट्टी के कणों की पुनर्व्यवस्था और डिबॉन्डिंग और साथ ही समग्र घनत्व में कमी को दर्शाता है। इसके अलावा, बल श्रृंखला वितरण, सरंध्रता, कण विस्थापन की भी जांच की जाती है।

इसके अलावा, परिमित तत्व विधि (एफईएम) का उपयोग करके दीवारों को बनाए रखने पर भूकंपीय लोडिंग के प्रभाव का अध्ययन करने के लिए सातत्य-आधारित संख्यात्मक अध्ययन किया जाता है। इनपुट पीक ग्राउंड एक्सेलेरेशन (पीजीए), दीवार की ऊंचाई बनाए रखने, मिट्टी के सापेक्ष घनत्व और गुरुत्वाकर्षण और ब्रैकट बनाए रखने वाली दीवार के कुल सक्रिय पृथ्वी जोर (पीएई) पर मिट्टी-संरचना संपर्क के प्रभाव की जांच की जाती है। पैरामीट्रिक जांच और प्रतिगमन विश्लेषण के आधार पर, पीएई के अनुमान के लिए पूर्वानुमानित समीकरण प्रस्तावित किए जाते हैं। इसके अलावा, त्वरण प्रवर्धन/डीएम्प्लीफिकेशन, विरूपण तंत्र और पृथ्वी दबाव वितरण के संदर्भ में गतिशील व्यवहार की जांच की जाती है। असतत विश्लेषण ने रिटेनिंग दीवार के समग्र व्यवहार के अंतर्निहित कण-स्तरीय तंत्र में मूल्यवान अंतर्दृष्टि प्रदान की, जिससे इसकी सातत्य प्रतिक्रिया की बेहतर समझ में योगदान हुआ। यह अध्ययन उन समीकरणों को विकसित करने में भी योगदान देता है जो तुलनीय कार्य वातावरण के तहत प्रारंभिक डिजाइन चरण में कुल सक्रिय जोर प्रदान करने के लिए अनुमानित हैं।

कीवर्ड: डीईएम, विरूपण, पृथ्वी का जोर, भूकंप भार, एफईएम, दानेदार मिट्टी, रिटेनिंग दीवार

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