

**LOAD TRANSFER MECHANISM OF CONNECTED AND
DISCONNECTED PILED RAFTS IN SAND – MODEL TESTING
AND ANALYSIS**

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**DEPARTMENT OF CIVIL ENGINEERING
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DISCONNECTED PILED RAFTS IN SAND – MODEL TESTING
AND ANALYSIS**

by

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Submitted

in fulfilment of the requirements for the degree of Doctor of Philosophy

to the



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OCTOBER 2021

*Dedicated to
Maa and Baba*

DECLARATION

I hereby declare that except where specific reference is made to the work of others, the contents of this thesis are original and have not been submitted in whole or in part for consideration for any other degree or diploma at this or any other university. This dissertation is entirely the result of my own work and includes nothing which is the outcome of work done in collaboration. The guidelines provided by the institute have been followed in preparing this thesis. This thesis contains less than 64,000 words and less than 120 figures.

Date:

Prasun Halder

New Delhi

CERTIFICATE

This is to certify that the thesis entitled “**Load Transfer Mechanism of Connected and Disconnected Piled Rafts in Sand – Model Testing and Analysis**”, submitted by **Mr. Prasun Halder** to the **Indian Institute of Technology Delhi**, is a record of bonafide research work carried out by him under my supervision and is worthy of consideration for the award of **Doctor of Philosophy** degree. The research reported in this thesis has not been submitted in part or full to any other university or institute for the award of any degree or diploma.

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ABSTRACT

The popularity of connected piled raft (CPR) system as foundation of high-rise building is huge because of its facility of simultaneous load sharing between piles and raft and effectiveness in reducing the settlement to an acceptable limit. However, the interactions between piles and raft makes the load sharing mechanism in CPR very complex and the accumulation of high axial stress and localized bending moment at the pile-raft connection might cause a sudden failure of the piles in high seismic and wind load dominant regions. To circumvent this problem, the innovative concept of disconnected piled raft (DPR) system, where the piles are structurally disconnected from the raft by a granular cushion layer, has emerged as a suitable and economic alternative to the CPRs. In this study, an attempt is made to investigate the fundamental aspect of load transfer mechanism of DPR and understand how it is different from that of a CPR system under vertical load. To fulfil this prime objective, scaled 1g physical model tests on CPR and DPR foundations are performed by varying pile spacing, pile length, raft thickness, cushion thickness and cushion granularity and the results are presented in a comprehensive and interesting manner. The settlement-dependent characteristics of pile-pile, pile-raft and raft-pile interaction factors in a CPR system under vertical load are evaluated experimentally and a simple mathematical model is proposed on the basis of these interaction factors and stiffness values of unpiled raft and pile group to estimate the loads shared by the piles and raft. The influences of cushion layer in terms of its

thickness and granularity on the performance of DPR i.e., settlement efficiency, structural behavior of piles and pile-raft load sharing are examined thoroughly and optimum values of cushion thickness and granularity are obtained from these test results. The effects of various geometric design parameters on the overall performance of CPR and DPR are studied as well. Lastly, 3-D finite element-based simulations are carried out to find out some intricate aspects of load transfer mechanisms of CPR and DPR which have not been addressed in the experimental study due to some limitations. Useful results are also presented to predict the behavior of prototype DPR system under vertical load. On the basis of the experimental results and findings from the numerical analyses, finally, some recommendations are provided regarding the design of DPR system which might be a viable and cost-effective alternative to the conventional CPR system for the low to medium rise buildings under vertical load.

Key words: Connected piled raft; Disconnected piled raft; Load transfer mechanism; Settlement efficiency; Pile-raft load share; Interaction factors; Model testing

सार

उच्च-वृद्धि वाली इमारत की नींव के रूप में कनेक्टेड पाइल राफ्ट (सीपीआर) प्रणाली की लोकप्रियता बहुत बढ़ी है क्योंकि इसमें ढेर और राफ्ट के बीच एक साथ लोड साझा करने की सुविधा और निपटान को स्वीकार्य सीमा तक कम करने में प्रभावशीलता है। हालांकि, पाइल्स और राफ्ट के बीच की बातचीत सीपीआर में लोड शेयरिंग मैकेनिज्म को बहुत जटिल बना देती है और पाइल-राफ्ट कनेक्शन पर हाई एक्सियल स्ट्रेस और लोकलाइज्ड बेंडिंग मोमेंट का संचय उच्च भूकंपीय और विंड लोड प्रमुख क्षेत्रों में पाइल्स की अचानक विफलता का कारण हो सकता है। . इस समस्या को दूर करने के लिए, डिस्कनेक्टेड पाइल राफ्ट (डीपीआर) प्रणाली की अभिनव अवधारणा, जहां ढेर को एक दानेदार कुशन परत द्वारा छत से संरचनात्मक रूप से काट दिया जाता है, सीपीआर के उपयुक्त और आर्थिक विकल्प के रूप में विसर्जित हो गया है। इस अध्ययन में, डीपीआर के लोड ट्रांसफर मैकेनिज्म के मूलभूत पहलू की जांच करने और यह समझने का प्रयास किया गया है कि यह वर्टिकल लोड के तहत सीपीआर सिस्टम से कैसे अलग है। इस प्रमुख उद्देश्य को पूरा करने के लिए, सीपीआर और डीपीआर नींव पर स्केल किए गए 1 जी भौतिक मॉडल परीक्षण ढेर के अंतर, ढेर की लंबाई, राफ्ट मोटाई, कुशन मोटाई और कुशन ग्रैनुलैरिटी द्वारा किए जाते हैं और परिणाम व्यापक और दिलचस्प तरीके से प्रस्तुत किए जाते हैं। ऊर्ध्वाधर भार के तहत एक सीपीआर प्रणाली में ढेर-ढेर, ढेर-बेड़ा और बेड़ा-ढेर अंतःक्रियात्मक कारकों की निपटान-निर्भर विशेषताओं का प्रयोगात्मक मूल्यांकन किया जाता है और इन अंतःक्रियात्मक कारकों और बिना ढेर के कठोरता मूल्यों के आधार पर एक सरल गणितीय मॉडल

प्रस्तावित किया जाता है। ढेर समूह ढेर और बेड़ा द्वारा साझा किए गए भार का अनुमान लगाने के लिए। डीपीआर के प्रदर्शन पर इसकी मोटाई और ग्रैनुलैरिटी के संदर्भ में कुशन लेयर के प्रभाव यानी, सेटलमेंट दक्षता, पाइल्स के संरचनात्मक व्यवहार और पाइल-राफ्ट लोड शेयरिंग की अच्छी तरह से जांच की जाती है और इन परीक्षण परिणामों से कुशन की मोटाई और ग्रैनुलैरिटी के इष्टतम मूल्य प्राप्त किए जाते हैं। सीपीआर और डीपीआर के समग्र प्रदर्शन पर विभिन्न ज्यामितीय डिजाइन मापदंडों के प्रभावों का भी अध्ययन किया जाता है। अंत में, सीपीआर और डीपीआर के लोड ट्रांसफर तंत्र के कुछ जटिल पहलुओं का पता लगाने के लिए 3-डी परिमित तत्व-आधारित सिमुलेशन किए जाते हैं जिन्हें कुछ सीमाओं के कारण प्रयोगात्मक अध्ययन में संबोधित नहीं किया गया है। वर्टिकल लोड के तहत प्रोटोटाइप डीपीआर सिस्टम के व्यवहार की भविष्यवाणी करने के लिए उपयोगी परिणाम भी प्रस्तुत किए जाते हैं। प्रयोगात्मक परिणामों और संख्यात्मक विश्लेषणों के निष्कर्षों के आधार पर, अंत में, डीपीआर प्रणाली के डिजाइन के संबंध में कुछ सिफारिशें प्रदान की जाती हैं जो ऊर्ध्वाधर के तहत निम्न से मध्यम वृद्धि भवनों के लिए पारंपरिक सीपीआर प्रणाली के लिए एक व्यवहार्य और लागत प्रभावी विकल्प हो सकती हैं। भार।

मुख्य शब्द: जुड़ा हुआ ढेर बेड़ा; डिस्कनेक्ट किया गया ढेर बेड़ा; लोड ट्रांसफर तंत्र; निपटान दक्षता; ढेर-बेड़ा लोड शेयर; इंटरैक्शन कारक; मॉडल परीक्षण

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