



Ain Shams University
Faculty of Engineering
Structural Engineering Department

Behavior of Dry-Stack Interlocking Masonry walls Under Out-of-Plane Loading

A Thesis Submitted in Partial Fulfillment of the Requirements for the degree of
Master of Science in Civil Engineering
(Structural Engineering)

by

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Statement

Disclaimer

This thesis is submitted as partial fulfillment of the Requirements for the degree of Master of Science in Civil Engineering, Faculty of Engineering, Ain Shams University.

The work included in this thesis was carried out by the author during the Period from 2011 to 2016, and no part of it has been submitted for a degree or qualification at any other scientific entity.

The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

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إقرار

هذه الرسالة مقدمة في جامعة عين شمس – كلية الهندسة ، قسم الهندسة الإنشائية للحصول على درجة الماجستير في الهندسة المدنية. إن العمل الذي تحتويه هذه الرسالة قد تم إنجازه بمعرفة الباحث سنة 2016.

هذا و يقر الباحث أن العمل المقدم هو خلاصة بحثه الشخصي – و أنه قد اتبع الأسلوب العلمى السليم فى الإشارة إلى المواد المؤخوذة من المراجع العلمية كل فى مكانه فى مختلف أجزاء الرسالة.

وهذا إقرار مني بذلك،،،،،

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ABSTRACT

The search for appropriate, easy, fast and cost effective ways for wall construction has lead to a promise technique known as “Dry-stack interlocking masonry system”. Nevertheless, there are several disadvantages with this system. One of the major drawbacks of this system is the low bending capacity that can be resisted with the interlocking keys alone. To overcome this problem, grouting and reinforcing of the hollow block cells is required which makes the system a bit expensive. Additionally, the dry-stacked units had to settle down to balance uneven surfaces and notches. One method that has been suggested to minimize these drawbacks is post-tensioning of dry-stacked units which lead to elimination of grout and reinforcement without affecting the bending capacity. Thus, construction can be faster and with minimum cost.

The objective of the current research is to investigate the behavior of post-tensioned dry-stacked interlocking masonry walls constructed using locally produced masonry units and prestressing bars under out-of-plane loading. Some of the factors expected to affect the performance of these systems are addressed, namely: construction system, grouting effect, post-tensioning technique and restraining effect of post-tensioning bars.

In order to design the test program, properties of all used materials were investigated then a pre-test analysis was carried out to determine the initial post-tensioning level and predict the lateral load capacity, internal forces at ultimate stage, and failure mechanism.

To assess the out-of-plane behavior of dry-stack interlocking masonry walls, twelve vertically spanning walls (loading span perpendicular to the bed joint) and six horizontally spanning walls

(loading span parallel to the bed joint) were constructed and tested under monotonic out-of-plane loading. The test results of each wall were presented in the form of Failure Modes, load – deflection curve, and load – post-tensioning force curve.

Key experimental results showed the similarity in the out-of-plane behavior of locally produced dry-stack interlocking masonry system compared to the conventional masonry system. UngROUTED PT walls had proved to be the most effective construction detail such that; it's load/weight ratio ranges between 1.3 to 1.6 times that of grouted PT walls, in addition to taking the advantage of minimizing construction cost, time, and weight of the structure. Additionally, load can be applied immediately after construction. Post-tensioned grouted walls showed a great enhancement in the cracking load nearly 3 times that of ordinary reinforced walls with a slight degradation in the ultimate load, thus, improving durability, preventing shrinkage cracking, and enhancing appearance under service loads. Unrestrained post-tensioning bars had a negative effect of about 45% reduction of the ultimate strength of ungrouted walls. Horizontal Post-tensioning technique greatly improves the out-of-plane behavior parallel to bed joint where it can achieve a cracking load 5 times that of traditionally joint reinforced wall and an ultimate load 4 times that of traditionally joint reinforced walls with taking the advantages of eliminating grout and its consequent advantages (time, cost, and weight).

Keywords: Dry-stack Masonry; Out-of-plane Behavior; Post-tensioned Masonry; Interlocking Masonry; Mortarless Systems.

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