Test ed analisi sui muri eretti con copertoni imbottiti di terra compressa

Riassunto (pag 2)

Questo studio testa i copertoni imbottiti di terra compressa per determinare i coefficienti di frizione cinetica tra i copertoni stessi e tra essi e il suolo. I risultati dei test determinano la pressione massima di terra compressa alla quale può essere sottoposto un muro autoportante e determinano gli indici di pressione massima laterale che il muro può ricevere dal peso di un tetto (the largest pressures a wall receiving horizontal lateral support from a roof system may receive). Sono stati eseguiti test sulla distorsione di un singolo copertone fino a 490 chili, ed è stato inoltre costruito un muro in piccola scala per testarne la resistenza ai carichi trasversali. (A deflection test is carried out on a single modified rammed earth tire up to 1080 pounds, and a small scale wall is built and tested for resistance to transverse loads.) Infine, basandosi sui risultati di questo report, è stata disegnata e analizzata dal punto di vista strutturale una casa. Grazie ai risultati di queste analisi si ritiene che i muri eretti con copertoni imbottiti di terra siano un modo sicuro e affidabile di costruire edifici ad un piano

Discussione ed analisi dei risultati (da pag 46)

Test sull'attrito

I test sull'attrito sono i più rilevanti per quanto riguarda la sicurezza degli edifici ad un piano costruiti con copertoni imbottiti di terra. Le Figure 29 e 30 e le Tabelle 6 e 7 mostrano i risultati dell'analisi di un muro autoportante. Si spera che questi risultati possano servire a classificare queste strutture e aiutino ad erigere piccole costruzioni come muri di contenimento per giardini o manufatti simili.

Le Figure 31 e 32 e le Tabelle 8 e 9 mostrano i risultati dell'analisi d'attrito quando la parete è concepita per sostenere una struttura laterale per il tetto. (display the results of the friction analysis when the wall is assumed to receive lateral support from a roofing system.)

Si può notare che per i copertoni R14 e R15 è più facile che le pareti crollino per ribaltamento piuttosto che per slittamento. (walls are more likely to fail from overturning as opposed to sliding.)

In entrambi i casi per pareti dall'altezza realistica di 2,3 metri e oltre, può succedere che siano sufficienti 4,1 Bar a causare un crollo. (It may also be seen that in either case, for realistic sized walls of 7.5 feet or higher, it would take over 60psf to cause failure.)

Dalla relazione Griepentrog, la pressione della terra sulla strutta curva avrebbe dovuto essere di tra i 2 e i 3 Bar. Il fattore di sicurezza è quindi di almeno 1.5, ovvero una sicurezza standard. (From the Griepentrog report, active soil pressures around the Weaver site were expected to be in the 30-40 psf range. The factor of safety is then at least 1.5, which is standard.)

Si deve anche notare che questi risultati sono basati su parametri molto prudenti. Come già accennato, il coefficiente di attrito dinamico è stato usato al posto del coefficiente di attrito statico. Anche se i coefficienti non possono discostarsi di molto, bastano piccoli cambiamenti per modificare le equazioni in larga misura. It should also be noted that these results are very conservative. As already mentioned, the coefficient of kinetic friction has been used instead of the coefficient of static friction. Although the coefficients may not differ drastically, small changes may carry through the equations for large effect.

E' molto importante notare che la forma a U di queste costruzioni rinforza ulteriormente la struttura. Inoltre, in molte case di questo tipo, i muri di contenimento sono collegati ad altri muri che assorbono la pressione laterale, diversamente da …….. (as opposed to the transverse resistance that the actual retaining walls provide.)

Nei modelli concepiti con supporto laterale, solo ………. è ipotizzabile. (In the models assuming lateral support, only horizontal lateral support from the roof system is assumed.)

Il supporto verticale/laterale addizionale dato dal muro adiacente a quello di contenimento accresce significativamente la sua solidità di quest'ultimo.

The additional vertical lateral support from the walls adjacent to the retaining walls will significantly increase the strength of the retaining walls.

Dato che il fattore di sicurezza è di 1.5, l'ulteriore rafforzamento delle pareti di un modello già basato su criteri di prudenza molto elevati, assicura che queste strutture sono in grado di fornire un supporto affidabile per le case a un solo piano. (Given that the factor of safety is already at 1.5, allowing for the increased strength of the walls due to the conservative nature of the model will ensure that these structures are capable of providing dependable support for one-story homes.)

Come discusso nella relazione Griepentrog, queste mura ricevono la loro forza dalla loro massiccia dimensione e dagli agli alti coefficienti di attrito. (As discussed in the Griepentrog report, these walls receive their strength from their massive size and large friction coefficients.)

Test sulla deviazione

The deflection results were fit using two different formulas, a linear fit, and an exponential decay fit. It is clear from Figures 24 and 25 and the associated R^2 values that the exponential fit defines the data better. This conclusion further makes sense because as the already highly compacted soil experiences additional loading, it has a limited amount that it can further be compacted. Additionally, the radial reinforcing steel wires under the treads of the tires ensure that the tire cannot continue to stretch horizontally. As a result, there is an upper limit on the deflection the tires can experience. From the best-fit curve equation in the exponential model, it can be assumed that each row of tires will not deflect more than .215 inches. Thus, if a house design called for 8-foot tall ceilings, and assuming 7 inches per row of tire, it would be conservative to assume 14 rows of tires to create a ceiling height of 8 feet 2 inches. At most there will be 3 inches of deflection due to loadings on the tires, resulting in a minimum 7 foot 11 inch ceiling. This is the case which is assumed in the house design below.

Wall Tests

As already mentioned, the wall failed under a load of approximately 1200 pounds and was expected to fail around 2250 pounds. There are many reasons that this failure may have been early. As mentioned previously, the wall was constructed with the half tires on the outside of the rows as opposed to standard building practice which places them on the inside of rows. Secondly, the uniform load applied over four rows of tires may have contributed to partial local failures as opposed to the global failure the models are based on. Finally, the wall was loaded twice to over 800 pounds and fully relaxed before the final load of 1200 pounds. This may have in fact tested the wall for a failure closer to fatigue failure than to the ultimate strength test that the wall was designed for. It is believed that due to these reasons the test is not conclusive or representative of the actual strength of modified rammed earth tire walls.

House Design

For the last part of the project, a single story home built out of modified rammed earth tires was designed and analyzed. Figure 33 displays the design of the house. The house was analyzed for both the soil pressure on the retaining walls as well as the resistance of the walls to earthquake loads. The calculations may be found in Appendix A. It was already found that the factor of safety for an eight-foot retaining wall is 1.5 of greater. It was found that conservatively using R14 tires, the factor of safeties involved in both resistance to sliding and resistance to overturning in Swarthmore, PA and in Taos, NM were not lower than 2.3. This suggests in a real world example that single story homes made from modified rammed earth tires will be safe under all regular loadings that they might incur.

Please note that the earthquake analysis was done to best represent an earthquake loading. It is often assumed that parts of building higher off the ground receive larger earthquake loads. To perform the EQ analysis, it was assumed that the roof load acted at the roof, contributing a large point load to the top of the wall. Additionally, it was assumed that the earthquake load on the wall acted as an inverse triangular load, smallest at the bottom and largest at the top.

Conclusion

Based on the tests and analysis of R14 and R15 rammed earth tire walls, it is believed that they are capable of providing safe and reliable support in single story homes. Although some of the factors of safety approach a lower limit of 1.5, it should again be noted that the models used in this report are quite conservative and the structures will be capable of withstanding larger forces than are computed within this report. Furthermore, from the Griepentrog report it has been concluded that loads applied to foundation soils suggest that it is acceptable to construct these homes directly on undisturbed soil, assuming specific site based investigation are carried out.

Finally, many of the ABET constraints discussed in the introduction were considered throughout the project. It is believed that these homes offer environmentally sustainable alternatives to standard building practices that may be built more economically than many other standard constructions.

Future Work

The most meaningful future work that could be carried out would be continued testing of walls. Tests of both laterally supported and un-laterally supported walls in both transverse and longitudinal loading would further characterize the strength of these structures. Furthermore, based on the wall testing in this report, fatigue-loading tests on the walls could also yield meaningful results.