PGA Geopier®

PGA Geopier Philippines Inc.

"The Alternative to Deep Foundations"

The Geopier system is a cost-effective solution to foundation support on soft soil sites and provides an excellent alternative to deep piles/caissons and overexcavation and replacement filing.

A Geopier element is a dense, aggregate pier constructed in a pre-excavated cavity with patented equipment that imposes lateral prestress into the undisturbed soils surrounding the element.

The combination of constructing the piers in pre-excavated cavities and the lateral stress build-up that result from the patented ramming equipment, are the key elements that set the Geopier system apart from all other aggregate pier or stone column systems. They are the primary factors accounting for the phenomenal success in controlling foundation settlements in soft soils.

Pier cavities are typically excavated by conventional drilling techniques, using either truck-mounted augering equipment or "dangle drill" equipment mounted on an excavator or crane. Drilled cavities for Geopier elements are typically 30" in diameter.

With the use of casing, Geopier elements can be constructed below ground water in all soil ranging from peat to loose clean sand to soft clays.

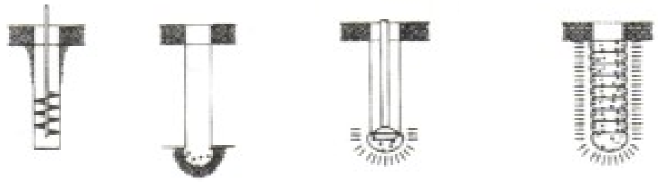
Aggregate used for pier construction is typically high quality crushed rock, such as used for highway base course. For liquefaction mitigation, free-draining aggregate can be used so the Geopier elements also functions as a drain to relieve excess pore water pressures.

Geopier elements are constructed in lifts of about 12" thickness, with each lift rammed vertically and laterally using the patented Geopier tamper. Within 15 seconds of tamping, a lift can receive over two times the compactive energy that is put into the maximum density laboratory test (ASTM 1557).

By constructing Geopier elements in clusters spaced from about 1½ to 3 diameters apart, the Geopier-reinforced soil mass experiences significant prestressing, which greatly improves its strength and consolidation characteristics (extending several feet beyond the outside piers). Hence, the so-called "group effect" is very desirable for the Geopier system because it improves performance (whereas, in the design of pile foundations the group effect is normally avoided because it tends to reduce individual pile capacities).

The Geopier system is applicable in any situation where a significant increase in stiffness and/or shearing strength of a soil mass will improve engineering performance. This includes:

Spread Footing - increase in bearing capacity and reduction of settlement.
Floor Slab/ Mats - Improves sub-grade uniformity and reduce settlements.
Slopes - Increase in factor of safety for Stability.
Excavation - Increase in temporary support.



1. Make Cavity
2. Place stone at bottom of cavity
3. Make a bottom bulb, density and vertically prestress matrix soils beneath the bottom bulb.
4. Make undulated-sided Geopier shaft with 12-inches (or less) thick lifts. Build up lateral soil pressures in matrix soil during shaft construction. Use well-graded base course stone in Geopier element shaft above ground water levels.

Fig. 1.1 Typical Construction Process

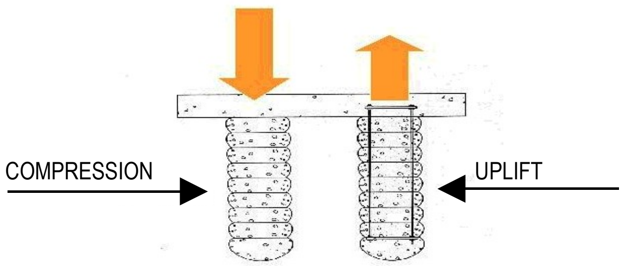


Fig. 1.2 GEOPIER can function both as Compression & Tension Piles

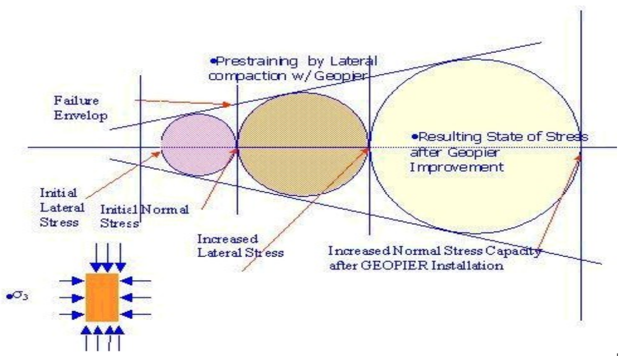


Fig. 1.3 Theoretical Mohr's Circle Representation of GEOPIER Soil Improvement

Fig. 1.4 Typical GEOPIER Construction Equipment consisting of Auger, Tamper and Feed Loader.

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Website : www.geopiers.com / www.pgatech.com.ph
E-mail : pgageopier@pgatech.com.ph

S & R PRICEMART
Foundation and Slab Support
Ortigas Avenue Extension, Pasig City

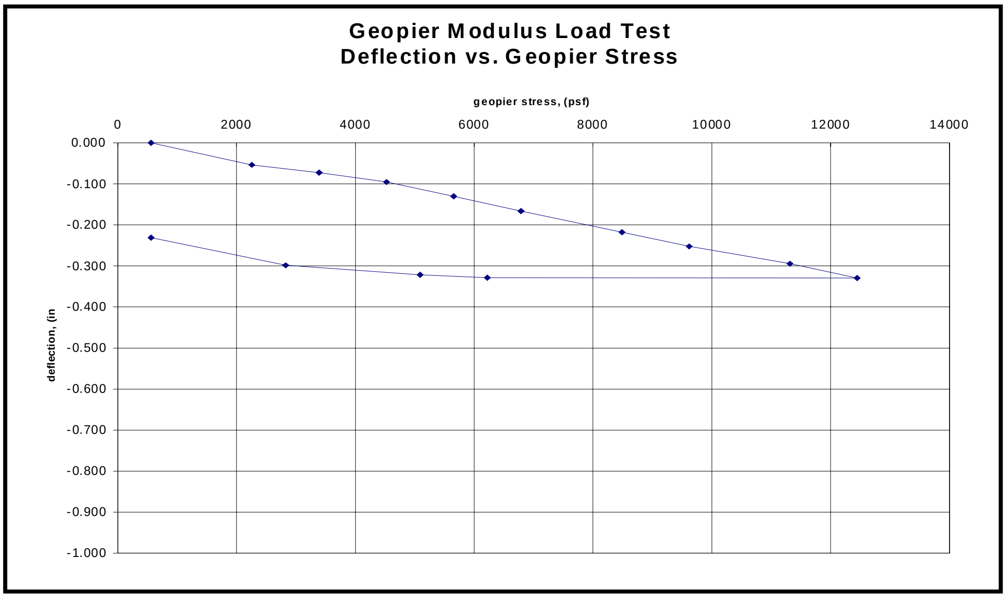
Description: 6,500 square meters retail store in suburban Pasig city with maximum column loads of 120 kips and floor slab pressure of 200 psf and 400 psf on some areas.

Subsurface Conditions: Soft swamp soils extending up to 18 meters below ground. Ground water table is at 1.20m deep.

Design Details: Original design called for suspended structural slab supported by drilled shaft / bored pile foundations. By adopting the Geopier floating foundation system, costly bored piling and suspended slabs were eliminated. This allowed the heavily loaded floor slab to be supported by the Geopier soil reinforcement and designed as a slab on grade. A total of 1,900 Geopiers with lengths of 3.0 to 3.5 meters were installed in 60 working days. With the construction of Geopiers, approximately **US$ 400,000.00** savings were realized and **COMPLETION TIME** was shortened by **TWO MONTHS** due to elimination of the suspended structural floor.

Geopier Licensee	:	***PGA Geopier Philippines, Inc.***
Owner	:	***PSMT Price Membership Club***
Reference	:	***Don Mcmillan, Sr. Construction Manager, PSMT***

PGA Geopier crew on the job at S & R Ortigas, Pasig City



Result of Modulus Load Test

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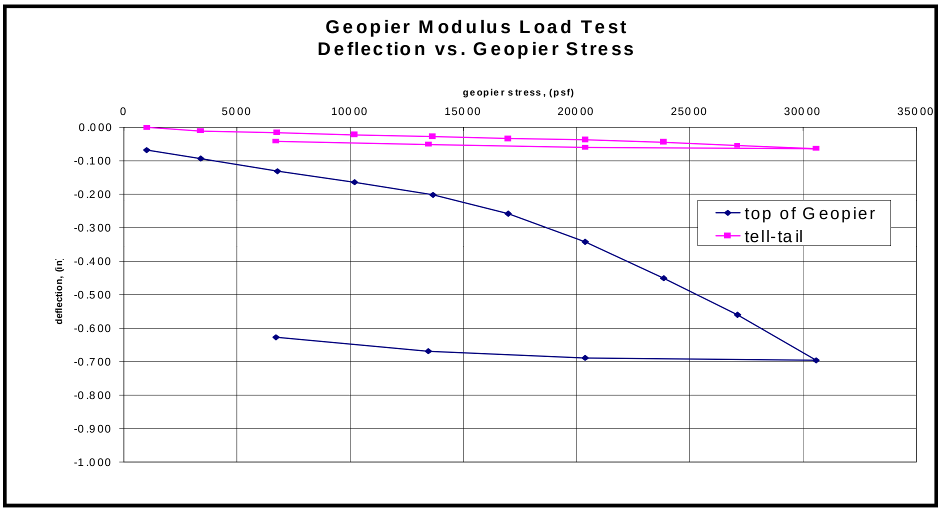
CALTEX NAPHTHA SPLITTER COLUMN
Foundation Support
Caltex Refinery, San Pascual, Batangas

Description: Foundation support for a 42.0m high Naphtha Splitter Column with a total compressive load of 2400 kips and a total uplift load of 200 kips.

Subsurface Conditions: The geotechnical investigation revealed medium dense silty sand materials down to 5.0m deep below EGL at the time of boring. However, there is an intervening very poor loose layer detected from 2.05m to 3.5m *(or approximately 1.0m thick).* Ground water table is at 1.80m depth below EGL at the time of boring.

Design Details: Various foundation solutions were considered for the project bythe client including excavation, bored piling, driven-piles and micropiles among others. The shallow water level would pose difficulty for the deep excavation. Bored piling proved to be very costly. Driven-piles and micropiles were ruled out as these have very limited flexural capacity and may prove inadequate for the expected moment due to lateral loadings. In addition, vibrations during pile driving can affect sensitive process instrumentation. Jet grouting would have been an efficient solution but the substantial cost savings being offered by the Geopier soil reinforcement system made it the most attractive alternative and the Geopier solution resulted in a **savings of US$ 20,000.00** over the Bored Piling option. A total of 24 Geopier soil-reinforcing elements, 16 of which were outfitted with tension harness to take care of uplift loads. The remaining eight (8) are compression Geopiers extending to a depth of 4.0m. The modulus load test result measured a deflection of 10mm at 100% of maximum design stress, which is equal to the predicted settlement. It is interesting to note that during the hydrotesting conducted on the naphtha cracker, the monitored settlement is less than 7mm.

Modulus Load Test Setup



Result of Modulus Load Test

Geopier Licensee	:	***PGA Geopier Philippines, Inc.***
General Contractor	:	***JGC Philippines, Inc.***
Reference	:	***Mr. Eric Tanjutco, Hambe Vargas, JGC Phils., Inc.***

STALDER BUILDING
Foundation Support
Dapitan Street, Sampaloc, Manila

Description: Four storey commercial building located in a 220.0 square meter lot in a flood prone area in Manila with maximum column loads of 260 kips.

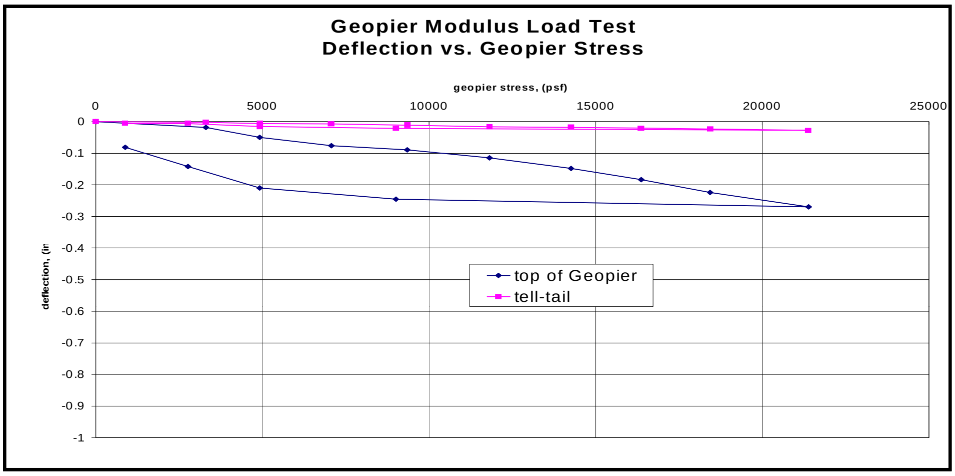
Subsurface Conditions: Based on the available soil investigation report, the subsurface soils consist of soft to very soft silty clays with sand to a depth of 6.0 meters. This is underlain by very stiff silty sand clays to a depth of 13.0 meters, and by very dense silty sand to about 19.0 meters. The depth of ground water is 1.40 meters below the existing grade.

Design Details: The original project design called for **mat foundation.** However, because of the danger of undermining the integrity of the adjacent building, whose foundations are relatively shallow and above the depth of excavation for the new building, the project manager opted for Geopier Intermediate Foundations.

In addition, the site is **flood prone** and has a very **shallow water table** making any excavation during monsoon next to impossible. The construction period was well within the rainy season. Because the site is underlain by very soft soils and muck, we had to utilize steel casing for some Geopier positions.

The recorded settlement during the modulus load test at maximum design pressure of 14,260 psf was **8mm.**

PGA Geopier crew setting up Modulus Load Test Frame for Stalder Project
Reult of Modulus Load Test



Modulus Test Result

Geopier Licensee	**:**	***PGA Geopier Philippines, Inc.***
Structural Designer	**:**	***Blas Espinosa***
Architect	**:**	***Abe D. Micu***
Owner	**:**	***Dina Dela Paz Stalder***
Reference	**:**	***Mr. Jose Roy Tarux, Project Manager***

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BITUMEN IMPORT FACILITIES
Ground Improvement Project
Tabangao Shell Refinery, Batangas City

Description: Ground Improvement for site of three (3) aboveground tanks T-7001 (20.0m Ø), T-7002 (12.5m Ø) and T-7003 (8.0m Ø) with average tank pressure of 5,140 psf, 2750 psf and 2,050 psf respectively and footing support for ancillary facilities which includes warehouse, control station, truck loading/gantry, pipe bridge with maximum compressive column load of 95 kips and an uplift load of 112 kips.

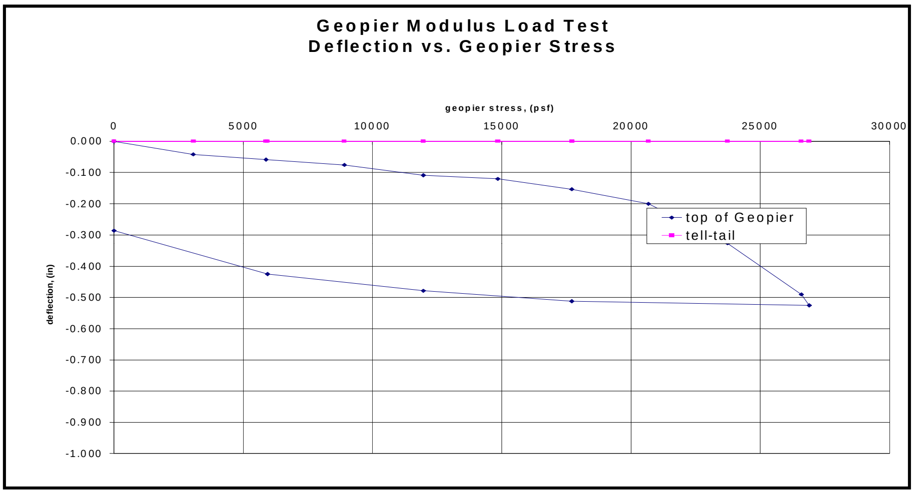
Subsurface Conditions: Soil borings on the site of the proposed Tank T-7001 indicate that the subsurface soils consist of loose to medium dense silty sand (SM and SM-SP) to a depth of 4.0 meters, underlain by loose to medium silty sand and silt to a depth of 15 meters (with a soft sandy clay layer from 10 to 11 meters deep).

Soil borings for the site of the proposed Tank T-7002 and Tank-7003 indicate that the subsurface soils consist of soft to stiff silty clay and very loose to loose silty sand and gravel to a depth of 3.0 meter, underlain by loose to medium dense silty and clayey sand to a depth of 21 meters. The groundwater depth was observed ranging from 1.5 to 2.5 meters below the existing grade.

Ground condition for the auxiliary facilities is similar to site of Tank T-7001 except for some areas containing buried materials consisting of Lime, Sulfur, Insulation, Coke and Refractor.

Design Details: Foundation options considered for the project includes Stone Column, Jet Grouting and Concrete Piles. Significant cost and construction time saving made Geopier soil reinforcement an attractive choice for the project. Also, the mitigating effect of Geopier soil reinforcement system on this **potentially liquefiable area** gave it the advantage over the other foundation systems. A total of 366 Geopier soil-reinforcing elements, 62 of which were outfitted with tension harness to take care of uplift loads, were installed for all three tanks extending to a depth of 4.0 m. Also, a total of 133 additional Geopier elements (57 compression geopiers and 76 tension geopiers) were installed for the ancillary facilities extending to depth ranging from 2.0m to 3.0m. The modulus load test for T-7001 measured less than **½** inch of deflection at 100% of maximum stress, which is much less than the predicted settlement of **2 ½** inches.

Modulus Load Test Setup



Resul of Modulus Load Test for Tank T-7001 where recorded settlement of 0.49 inch is much less than the predicted 2.1 inches

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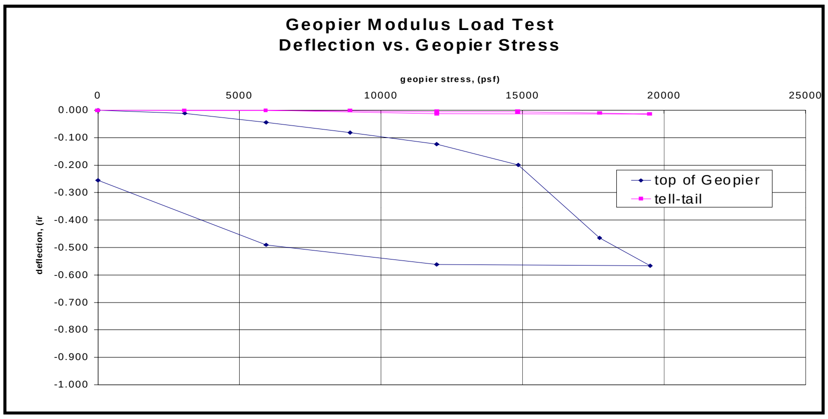
Another modulus test was performed for the buried materials area. Previous to this there is no recorded data on Geopier performance on ground with buried materials.

It was observed that the recorded settlements were much less than the values obtained during the first modulus test for each incremental loading. It was also noted that the Stress-Deflection curve registered a sudden drop only after the pier was subjected to stress levels exceeding those of the first modulus test.

The recorded settlement for the second modulus test were 0.13" (3.3mm) at 100% of design stress and 0.57" (14.4mm) at about 160% of the design load. It also registered a final deflection of 0.26" on rebound.



Modulus Load Test Setup

Despite the very stringent safety requirements of Shell refinery, the project was completed on schedule and without any safety infraction thereby earning for the ***PGA Geopier Philippines, Inc.*** a **HSSE Achievement Award** from ***Pilipinas Shell Petroleum Corporation.*** Hereunder is a copy of said award.

HEALTH, SAFETY, SECURITY AND ENVIRONMENT AWARD

presented to

PGA GEOPIER PHILIPPINES INC.

for the completion of
GROUND IMPROVEMENT OF BITUMEN IMPORT FACILITIES PROJECT
without injury, fire incident and property damage
from November 2002 to January 2003

A MILESTONE HSSE ACHIEVEMENT

Given on this 13th of February 2003 at
Pilipinas Shell Petroleum Corporation
Tabangao Refinery, Batangas City, Philippines

[illegible] CHENG
Engineering Manager
Pilipinas Shell Petroleum Corporation

ALFREDO T. [illegible]
Projects Manager
Pilipinas Shell Petroleum Corporation

Geopier Licensee : ***PGA Geopier Philippines, Inc.***

Designer : ***JGC Philippines, Inc.***

Owner : ***Pilipinas Shell Petroleum Corp.***

Reference : ***Mr. Dondi Paulino, Mr. Mario Monsalud, PSPC***

CBCP-NASSA Training Center
Foundation Support
Barangay Asisan, Tagaytay City

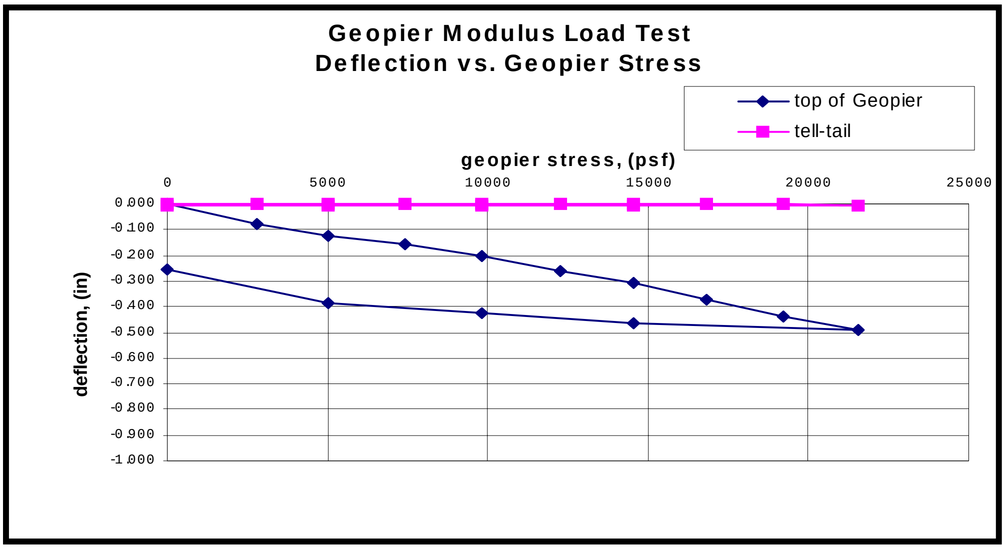
Description: The project includes a two-storey training center building with a Four (4) Storey Structure at the rear due to the sloping ground, consisting of 51 Rooms, a Cafeteria and Support Facilities including a Chapel. The design column loads range from 150 to 250 kips and column spans are 7.5 meters average but some are shorter.

Subsurface Conditions: The subsurface soils consist of 2.5 meters thick of soft silt (MH), with SPT-N values ranging from 1 to 10, and underlain by loose to dense silty sand (SM) to a depth of 7.5 meters, with SPT-N values of 4 to 35. A medium dense to dense gravel (GW) layer was encountered below 7.5 meters deep to the end of boring at 12.0 meters. Base upon the preliminary calculation information provide by your office, the groundwater depth was observed at 3.5 meters below the existing grade.

Project Description: After initial evaluation, Precast driven piles were ruled out due to the cost and also due to the variability in the depth of the bearing layer. The Project called for the installation of about 130-rammed aggregate piers with length varying from 2.5 to 3.5 meters. Installation was completed in 12 days despite the presence of typhoon for one whole week. Civil works commenced immediately a day after the first day of geopier installation, as there is no curing period to consider.

The result of the Modulus Load Test, which was conducted on June 23, 2003, was better than was anticipated in our design assumptions. The total settlement recorded for the pier when subjected to full service load is only 0.3 of an inch 7.62mm and failure was not reached at 1.5 times the maximum service load. A residual settlement of 0.27 inch 6.85mm was left after unloading the Modulus Load Test. (See attached Modulus Test Result).

PGA Geopier crew on the job at CBCP-NASSA Training Center



Modulus Load Test Result

Geopier Licensee : ***PGA Geopier Philippines, Inc.***

Structural Designer : ***EM2A + Partners***

Owner : ***Catholic Bishops Conference of the Philippines***

Reference : ***Rosalio P. Ponio, Project Manager***

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