Em Hotep
Egypt for the Curious Layperson and the Budding Scholar

Hemienu to Houdin: Phase One, Part A— Alternating Lanes and Building from the Inside Out

Posted by: Shemsu Sesen (Keith Payne) – February 2011

In *Hemienu to Houdin: Phase One, Part 1*, we looked at how Jean-Pierre Houdin proposes Hemienu could have built two thirds of the Great Pyramid with a straight, external ramp that only reached one third of the total height of the pyramid. We also outlined how the ramp would have been three ramps in one, or rather, a ramp of three lanes, two of which alternated from level to level.

In *Phase One, Part 2*, we will be taking a closer look at how the external ramp worked, how the different parts of the ramp and pyramid interacted, and the order of operations (i.e.: what parts were built in what order, and why). To do this we will be constructing a model of the pyramid from levels one to three, with a jump ahead to level 35 to examine how Hemienu would have needed to alter his strategy in order to maintain continuous uninterrupted work on the pyramid in Phase One. Our goal is a clear understanding of how the alternating lanes worked, and what "building from the inside out" means.

But when looking at our model it is important to understand that, like many of the graphics in *Phase One, Part 1*, our model is not to scale. To be specific, it is a small model with large parts. Rather than a scale depiction of the actual pyramid, our pyramid will be used to demonstrate concepts and methods. So while some *objects*, such as the facing stones, are shown larger than they would actually appear, some *areas*, such as the core, are shown in much smaller perspective than they would appear in relation to the whole.

We should also clarify some of the terminology we will be using. As in *Phase One, Part One*, the words *level* and *layer* will have specific technical meanings. But as we get into the minutia of the levels of the pyramid, the layers of the ramp, and the facing and backing stones, it will be more important than ever to understand these distinctions, so let's review:

- When referring to the horizontal courses of blocks that make up the pyramid, we will use *level*, as in ***level*** *one of the pyramid*, or, ***construction of the King's Chamber began at the fiftieth level***. The word *course* may also be used to refer to pyramid levels, but the word *layer* will never be used to describe a level/course of the pyramid.
- When referring to layers of the ramp, the word *layer* will be used. For example, we may refer to the *first* ***layer*** *of Lane A*, or we might say *both lanes are of equal height at* ***layer*** *thirty-five*. The word *tier* may also be used in reference to layers of the ramp, but the word *level* will never be used to describe a layer/tier of the ramp.

- With this in mind, a helpful equation to remember is: ***The ramp at layer* X *is used to build pyramid level* X + *1***. Thus, **layer five** (*X* = 5) of the ramp would be used to build **level six** (*X* + 1) of the pyramid.
- When referring to the layer of facing stones or the 20-meter thick backing layer between the facing stones and the core, the word *layer* will be used, but always with the *facing* or *backing* qualifiers. In other words, when layer refers to facing and backing layers on the pyramid, the context will always make it clear that we are *not* talking about layers of the ramp.

Before going on to our model we will first take a look at what "building from the inside out" means within the context of Jean-Pierre Houdin's theory.

Building from the Inside Out: A Primer

Another key concept of Jean-Pierre Houdin's theory of how the Great Pyramid was constructed is "building from the inside out." Broadly speaking, this refers to the process of transporting materials within the perimeter of the pyramid and building inward *from the surface to the core*. If you read *Six Letters from Hemienu* then you know that the pyramid was built in *layers (*in this case, we are obviously not talking about the *layers* of the ramp!). When you are installing layers of blocks from the surface toward the center, you have to push them into place from behind, thus, *building from the inside out*.

<<graphic of pushing block

So why does Jean-Pierre propose that Hemienu built the pyramid inward from the surface to the core? Why not build the layers by laying blocks at the far (northern) end and keep laying them row after row until the southern edge was reached? Or why not start in the center of the level and work outward, like laying floor tiles? Aren't most theories a variation on these two themes?

Yes, most theories incorporate one of these strategies, which is part of the reason why most theories can't work.

The problem with building a pyramidal shape, a geometric form wherein four sides of a square are extended upward and inward so as to arrive at a perfect apex, is that if the angle of *anything* is off, the entire shape fails. Jean-Pierre identified five parameters that Hemienu would have needed to keep under constant control to assure a true pyramid: the faces, the edges, the diagonals (corner to opposite corner), the north/south axis, and the east/west axis. The rudder by which he navigated these parameters was the level-by-level installation of the pyramid's smooth facing stones.

As described in *Six Letters from Hemienu*, the fine white limestone used to cover the outside of the pyramid had qualities that required it to be completely finished where it was quarried at Tura. This type of limestone was easy to extract and work with, but as soon as the air hit it, it began to calcify and harden. For this reason the masons had to immediately cut, shape, and polish the limestone on-site. Once it reached Giza it could be patched or repaired if it had sustained light damage, but it couldn't be reshaped. It either fit, or it didn't—no alterations!

As part of the finishing process, each facing stone was placed next to the stones that would surround it on the pyramid and then further shaped for a precise fit. In this manner, every course of facing stones was first preassembled at Tura and numbered for reassembly prior to transport. In essence, level-by-level the entire shell of the pyramid was built onsite at Tura and then shipped off to the worksite. It is easy to overlook the implications of this prefabrication of the pyramid's surface.

The shape of the prefabricated facing stones formed the mould into which the rest of the pyramid would be poured, and which controlled all five of the parameters. The outward slope of each block controlled the shape of the face, the angles of the cornerstones assured the edges, and the degree to which the entire assemblage was squared established the diagonals and axes. This is why the facing stones were the rudder that steered the construction—the stonecutters at Tura were not just quarrying blocks, they were creating the pieces of a 3D jigsaw puzzle that gave the pyramid its perfect shape.

The fact that the facing stones were prefabricated and had to be inserted into specific locations is also why they had to be installed first. Theories that depict the facing stones being installed last could not have worked because the facing stones could not be reshaped to fit the backing layer, the backing layer had to be custom made to fit behind the facing stones. So the facing stones had to be levered into place first, then came an immediate backing layer of custom-fit local limestone followed by the 20-meter thick layer of mass produced and well-cut two-ton backing stones, also locally quarried.

It is this well-calibrated layer of backing stones that greet us from the pyramid's face today. The gleaming Tura limestone that once covered the pyramid in a smooth layer from the foundation to the apex has disappeared, having been stripped away centuries ago for other uses. The yellow-brown limestone of the blocks we see now may not be as aesthetically appealing as the facing stones must have been, but it has some excellent qualities of its own.

The Giza Plateau is made up of a kind of limestone called *nummulitic*, so-called because of the fossilized shells of ancient marine life called *nummulites* frozen within it. These small coin-shaped (Latin *nummulus* = "little coins") life forms were the largest single-celled organisms ever to exist (Source: "Pyramids, forams, and Red Sea reefs: Field notes from Lorraine Casazza"). This peculiar biological quality makes them extremely durable as fossils, and this makes the limestone in which they are encased very dense and capable of supporting an enormous amount of weight—such as a pyramid.

Hemienu knew that the durable limestone from the local quarry was perfect for building the inner part of the pyramid, but it was not suitable for the smooth surface. The nummulitic fossils are much like gravel in modern concrete—they add hardness and strength. But this compound also makes the local limestone ill-suited for creating the perfectly smooth surfaces that were needed to maintain the constant angle of the pyramid's faces and edges. The easily worked Tura limestone was necessary for these precise shapes. Thus, the selection of the Tura limestone was both cosmetic and functional.

So the nummulitic limestone native to the Giza Plateau wasn't good for facing stones, but the large, precisely cut blocks of the pyramid's current surface made an ideal supporting layer that could bear the weight above it for, obviously, a very long time. And as with the facing stones, these two-ton blocks had to be transported with the perimeter of the level under construction and shoved into place from behind.

Another way in which Jean-Pierre's theory varies from many of the others is in his rejection of the idea that, behind the facing stones, the pyramid was constructed mostly of these well-calibrated blocks. Structurally speaking, the supporting layer of well-cut two-ton backing stones only needed to be about 20 meters thick (thus the oft-cited *20-meter thick backing layer*!). Most of the core of the pyramid could be made of much more roughly cut limestone blocks.

In fact, Jean-Pierre believes about seventy percent of the Great Pyramid's total mass consists of hastily quarried rough nummulitic blocks packed in with limestone chips and gypsum mortar. The result was a cruder but much quicker building process, and one which was perfectly suited to Hemienu's needs. Khufu's Master Builder was also a master of striking a balance between speed and precision. Never settle for less than needed, never do more than required.

There are, of course, parts of the core that are more solid than others. The interior structures undoubtedly have foundations of well-calibrated blocks, and Jean-Pierre contends that there would have been a section of the core near the southern face that would have been more solid in order to support the granite megaliths while they were being stored during construction of the King's Chamber. But for the most part the interior of the pyramid is rough core.

By the way, if the above process sounds familiar that is because it was foreshadowed in *Phase One, Part 1*, when we discussed how Jean-Pierre's theory describes the external ramp. The outer sides and central lane were constructed of the same well-calibrated blocks as the pyramid's backing layer, the core of the ramp was made the same way as the core of the pyramid, and the smooth paved surface was made of the same Tura limestone as the pyramid's face. Another of Hemienu's axioms seems to have been *when you find something that works keep doing it until it doesn't work anymore*.

So now that we have had this primer of how to build the pyramid from the inside out, and what to build it out of, let's take a look at the model to see the whole scheme in action.

The First Two Levels

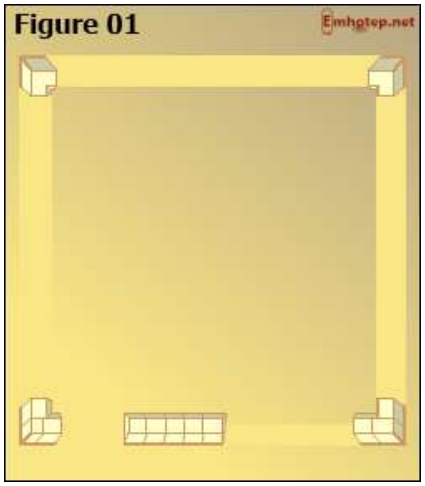
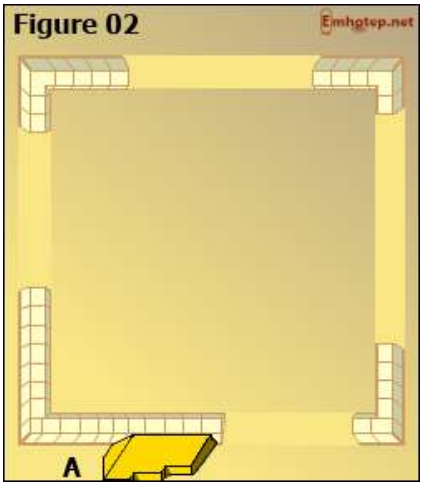
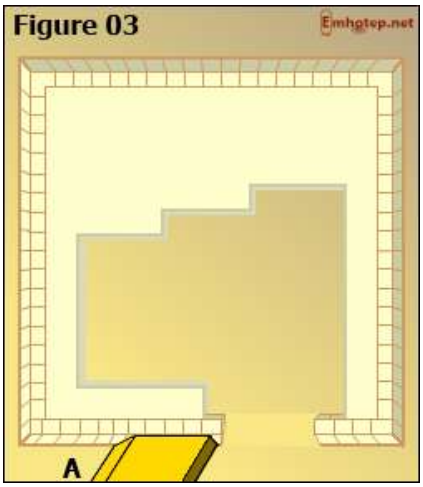


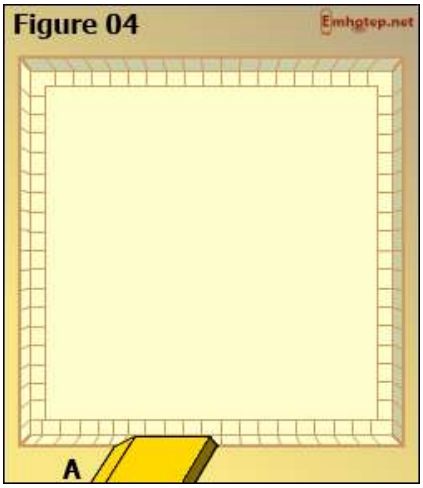
Figure 01 represents the very first stage of constructing the pyramid. The corner facing stones would have been installed and then teams of workers would extend these "walls" along the perimeter, meeting somewhere near the center of each face. This image also depicts the facing stones where the junction between the ramp and the pyramid would meet. This line of blocks would be among the first installed on any level (from the fiftieth down) because they form the backing for the ramp and establish the height for that layer



More of the facing stones are now in place as the "shell" for the first level continues to be installed. Construction of Lane A has also begun. Starting at the junction of the ramp and the pyramid's face, this horizontal tier would have been built toward the southwestern slope. Building from the pyramid toward the slope was a means for controlling the height of the ramp's horizontal layers—if the ramp builders started at the foot and built toward the pyramid it would have been difficult to maintain the correct height for the junction. By starting at the pyramid the correct height is set from the beginning.



In Figure 03 we see that the facing and backing layers have been nearly completed, with the perimeter left open in the southeast to allow building materials to be transported within. About a third of the core has been filled in as well. We will take a more detailed look at the interior when we cover “building from the inside out.” Meanwhile, Lane A continues to be extended toward the southwestern slope. Recall that there will be no inclining foot for the first six layers of the ramp—they will simply be horizontal tiers extending straight across to the slope where the plateau rises toward the southwest.



The first course of the pyramid is now finished. In a more literal depiction you would see that much of the western interior would actually be filled with a seven-meter high mound of limestone that was left in place to save time and effort. After all, why excavate the natural limestone just to replace it with limestone blocks? Another example of how Hemienu shaped the terrain to his advantage, this hill would have filled much of the core for the first six levels. In fact, this hill forms about one tenth of the total core of the pyramid.

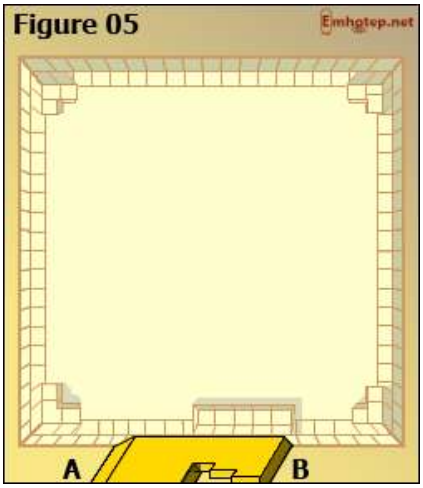
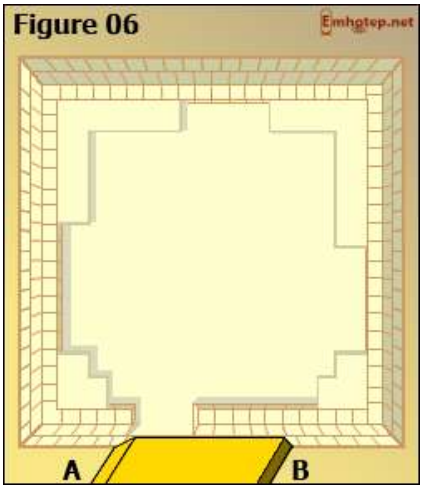
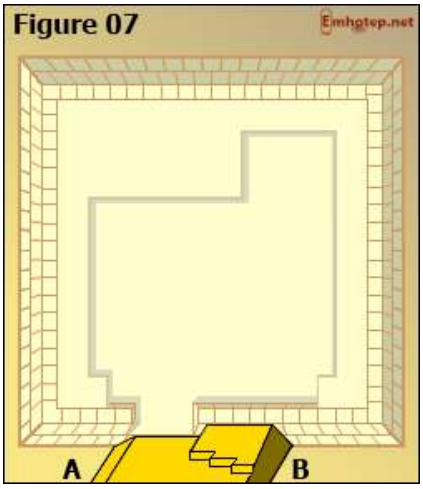


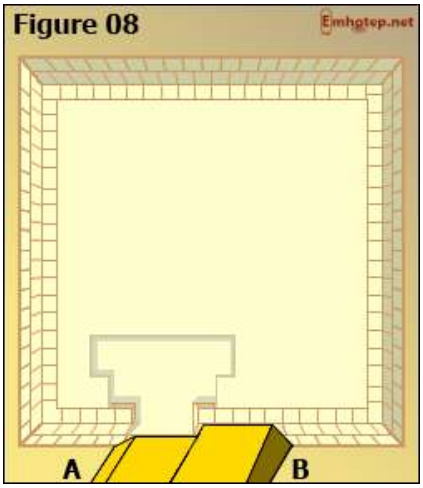
Figure 05 shows the beginning of the second pyramid level, as well as the beginning of the first layer of Lane B. Work on Lane B would in no way impede the pyramid workers because Lane A provides clear access to level two. The genius of the alternating-lanes ramp is that it always delivers unobstructed passage to the worksite without any interruptions in the building of the pyramid. When the builders are finished with the pyramid level they are working on, the ramp to the next layer is waiting for them. The key to a project as large as the Great Pyramid is always staying a step ahead of the next stage of work.



In Figure 06 the first layer of Lane B is now finished. Although not fully depicted in the graphic, both lanes extend from the face of the pyramid across the terrain to the incline formed by the southwestern slope. Both lanes now form a single horizontal tier the same height as pyramid level one, but the workers would still only be using Lane A to transport blocks because construction would immediately begin on the second layer of Lane B. All of the level two facing stones (except the gate at the junction) are shown in place, along with a large part of the 20-meter thick backing layer.



Here the second layer of Lane B is being constructed in preparation for building the third level of the pyramid. Keep in mind that the ramp at layer *X* is used to build pyramid level *X* + 1. In other words, Lane B at layer two (*X*=2) will be used to build pyramid level 3 (*X* +1). Layer two of Lane B is at the same height as the level two facing stones, and will maintain this height all the way across to the southwestern slope. Most of the 20-meter thick backing layer is shown in place, and the filling of the core is underway.



In Figure 08 we see that the second level of the pyramid is nearly complete—all that remains is to "plug the gate." The builders would continue filling the core with rough-cut blocks and limestone chips until they came to the threshold where the smoother blocks of the backing layer should resume. Once the gate in the backing layer was plugged, the builders would install the last section of facing stones for this level, which would close the junction between Lane A and pyramid level two. The builders would now switch to Lane B and work on level three of the pyramid would begin.

Building from the Inside Out

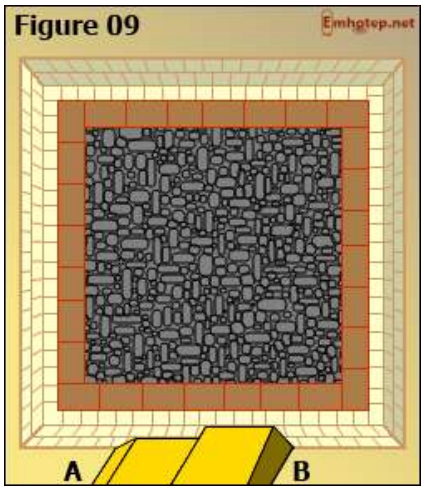


Figure 09 we resume with the second level of the pyramid completely finished. Lane A, which is still at layer one, comes to a dead end against the facing stones of level two and will now have to be raised two layers in preparation for building pyramid level four. But level four is still a little while in the future. The current project is pyramid level three, and Lane B (which is at layer two) is ready for action. So to summarize, Lane B is the active lane in the construction of pyramid level three, while Lane A will be elevated in preparation for building pyramid level four.

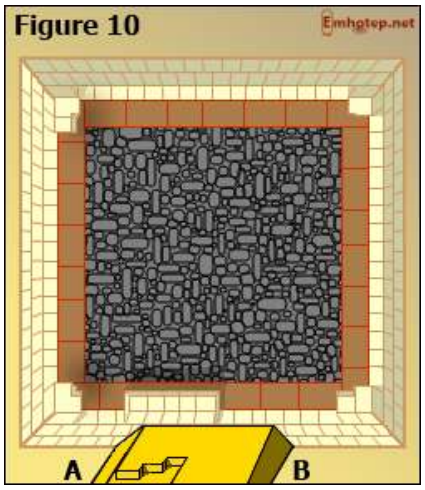
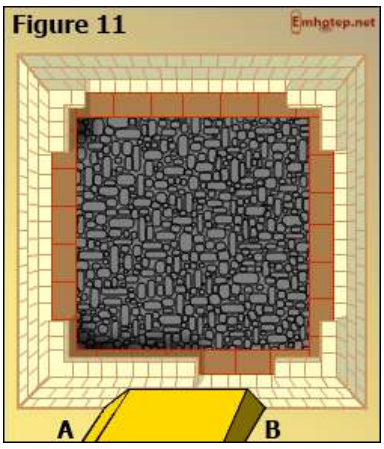


Figure 10 shows the beginning of work on Lane A, with the second horizontal layer being built on top of the first. The facing stones that will form the junction between the pyramid and the third layer of Lane A are already in place, along with the level three cornerstones. At this point teams of workers will have been assigned the sections of facing stones they will be responsible for installing. Competition would be on the rise as the team leaders (and their bosses!) would undoubtedly have placed wagers on who would finish their section first. Perhaps scores from this phase of level two will now be settled.



The installation of the facing stones for level three continues. Although not depicted in Figure 11, there would have been multiple sites along the perimeter where the builders would be levering blocks into place. Lanes A and B are shown at equal height, but the workers would only be using Lane B to transport building materials. Even if the second layer of Lane A was complete, there would be no time to make use of it before work began on layer three. Besides, the gap at the junction was only wide enough to accommodate traffic from a single lane.

But the ramp's design assured that a single lane would always be sufficient for the job at hand. The ramp was very wide at these lower levels, with the side lanes being 35 to 40 meters in width. This would have accommodated many sled teams on the ramp at once. Although the ramp will grow narrower with each layer, successive levels of the pyramid are also getting smaller, so while the number of workers able to fit on the ramp shrinks with each layer, the rate of work remains fairly consistent—it takes fewer workers at each level to keep up the pace.

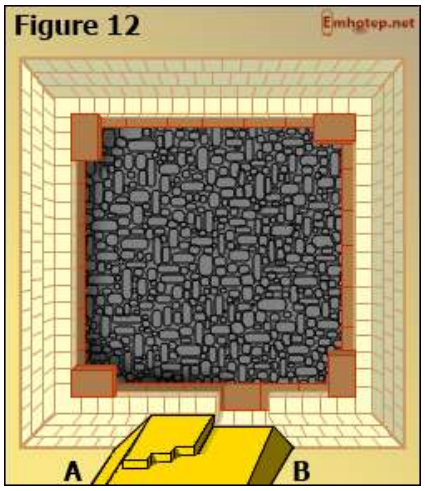


Figure 12 shows the third layer of Lane A under construction, its top flush with the top of the level three facing stones. With the exception of the junction, the entire facing layer of Tura limestone has been installed, and the workers have begun work on the corners of the 20-meter thick backing layer. Although most of the pyramid's mass consists of the rough-cut stones that fill the core, this supporting layer of precisely-cut two-ton blocks forms the true skeleton of the Great Pyramid that has enabled it to withstand the millennia, resisting everything from earthquakes to cannon fire.

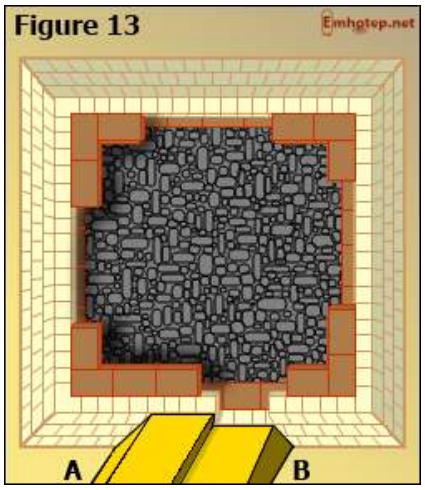
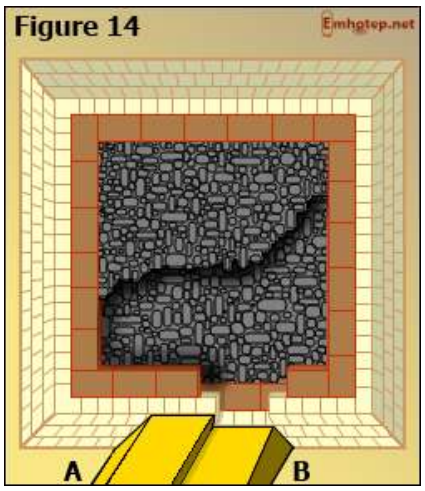


Figure 13 depicts the construction of the 20-meter thick backing layer in progress, with a little over half of the 2-ton blocks in place. As stated above with regard to the installation of the facing stones, there would actually have been numerous teams along the perimeter installing sections of backing stones, with block-laden sleds being rushed across the surface to these points of labor. Graffiti discovered within the pyramid and other structures indicates that the competitiveness of these teams generated an *esprit de corps* that is wholly incompatible with the notion that the pyramid was built by slave labor.



With the exception of the gate at the junction of Lane B, the entire level three backing layer is now complete, along with about half of the core. The quarrying and installation of the core material went more quickly because it did not have to be cut as precisely as the blocks that constitute the backing layer. Rough cut stones, still weighing an average of two tons each, were shoved into place as tightly as possible. Chips of limestone would have been poured into the cracks between the rough blocks and then pounded into tight, dense filler, supplemented with gypsum mortar.

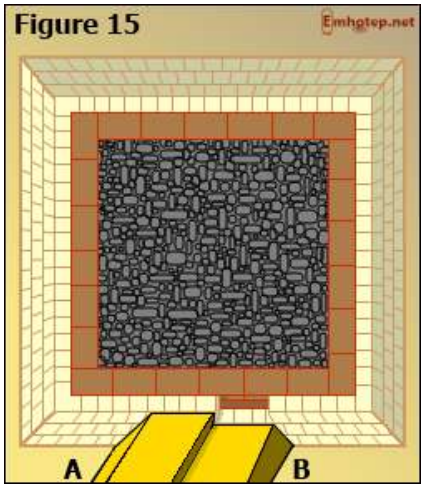
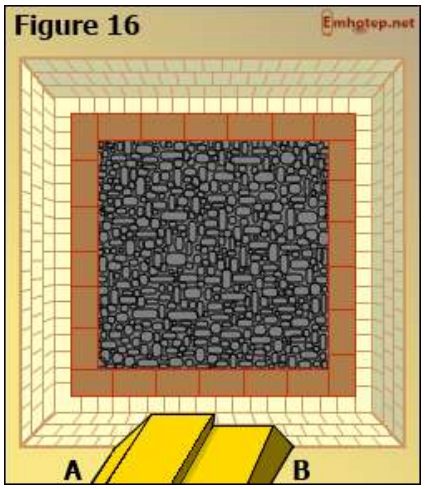


Figure 15 shows the core of level three completed, along with the junction now sealed off by the backing layer. In reality, the core would not have been leveled off quite as neatly with the facing stones and backing layer as depicted here. Jean-Pierre theorizes that the core was not always perfectly flush at each level, but was instead periodically leveled off as needed. The first such leveling occurred at level 23 (about 20 meters), which is the base of the Queen's Chamber. Another occurred at level 37 (about 32 meters), and a third at level fifty (43 meters), where the external ramp ends and Phase 2 begins.

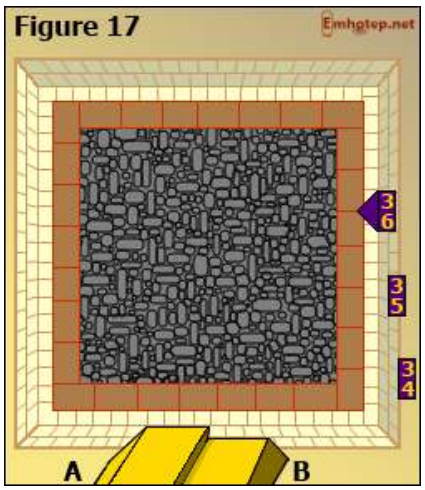


And another level is complete! Figure 16 is now an inverse image of Figure 09, only one level taller. Now it is Lane B that comes to a dead end against the facing stones of level three, and Lane A that is ready for action. The pyramid builders would now switch lanes again as work on elevating Lane B would commence and teams dragging sleds loaded with the smooth Tura facing stones would begin racing up Lane A to start construction of pyramid level four.

We have examined how the external ramp was used in the construction of the first three levels of the Great Pyramid, but now it is time to turn our attention to a required change in strategy. Once the ramp reached layer 35 it was too narrow to continue the two lane strategy. Hemienu knew he would have to start building the ramp with a single lane, but how could he do this without resorting to the go/stop strategy? How could he avoid work stoppages with a single lane ramp?

Fortunately, just as the ramp was getting narrower, each new section was also getting shorter and each level of the pyramid smaller. This gave Hemienu a little extra time at each level to invest in the pyramid itself, and Jean-Pierre proposes he made good use of it. Of course, being a Master Planner, this extra time was not simply good fortune, Hemienu would have had foreseen this potential bottleneck and planned for it from the very beginning.

The Ramp at Layer 35—a Combined Solution



In Figure 17 we resume our tale with level 35 of the pyramid complete. Lane A is at layer 35 and is ready for use in building pyramid level 36. Lane B is at layer 34 and comes to a dead end against the facing stones of pyramid level 35. Recall that one of the advantages of a ramp of horizontal tiers is that, unlike diagonal tiers, there is less to build with each successive layer. As the layers stack higher, the sloping foot gets closer to the pyramid and the horizontal layers get shorter. So raising Lane B to layer 35 will take considerably less time than in previous layers. Hemienu was counting on this in his design.

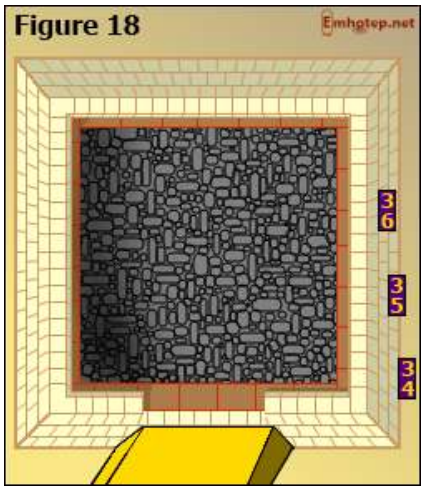
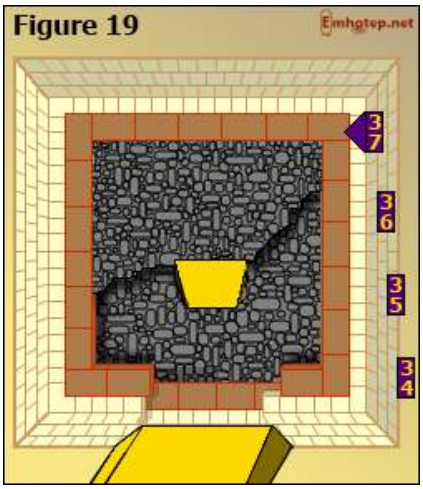
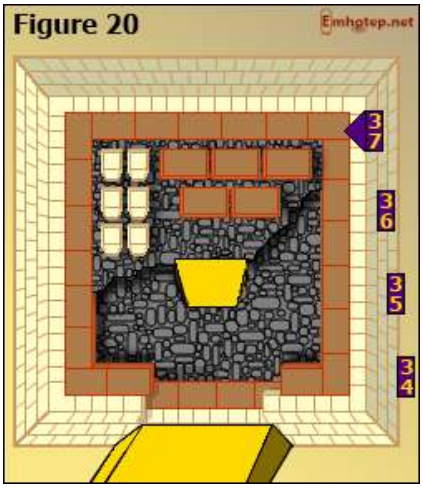


Figure 18 shows all of the level 36 facing stones installed, but note that the gate left open for the junction now spans both lanes. This is because from now on the external ramp will only have a single, wide lane. Technically there are still two lanes divided by the higher-quality central lane that will bear the 60+ ton granite slabs in Phase 2 (not shown), but there will no longer be different lanes at staggered heights. In other words, the lanes at layer 35 will remain there until the time comes to raise the entire ramp (all three lanes) to layer 36.

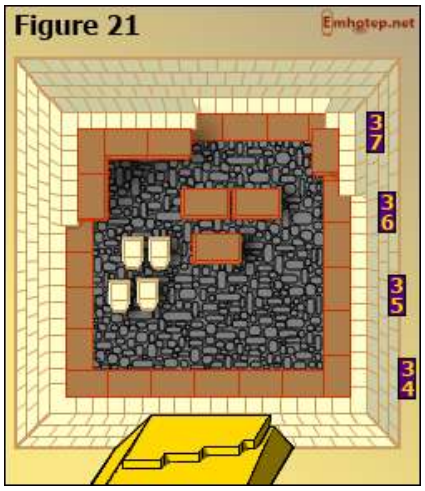
Incidentally, with the raising of Lane B to layer 35, traffic on the ramp effectively doubled. With the alternating lanes strategy abandoned, work on the ramp has stopped for now and both lanes (now one single wide lane) are open to traffic. Without “Men at Work” causing obstructions on half of the ramp, twice the number of workers can use it at the same time. This boost in productivity was also anticipated by Hemienu’s design.



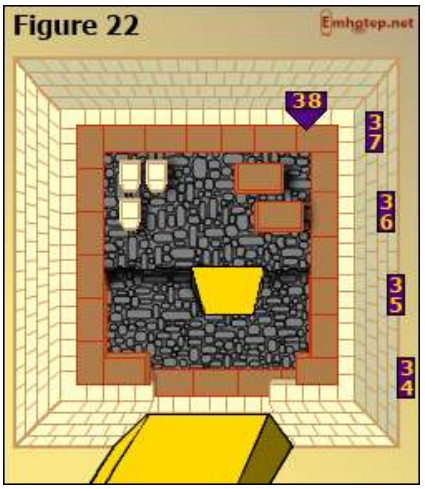
We now get a hint of how Jean-Pierre believes Hemienu was able to keep work flowing on the pyramid, even when the ramp was closed due to construction. Just as both lanes are now open for use, the entire ramp would have to be shut down when it came time to raise it a layer. But work stoppages on the pyramid itself could still be prevented. In Figure 19 we see that a small ramp has been constructed that connects the incomplete level 36 to level 37. This ramp would only be a meter or so high, but it was the key to keeping the pyramid on schedule.



With pyramid level 36 still incomplete, Figure 20 shows building materials that have been stockpiled on level 37 via the mini-ramp. Having calculated how long it will take to build layer 36 of the ramp, Hemienu has lain up enough materials to keep the workers busy on level 37 of the pyramid while the ramp is under construction. The surge of extra labor and materials allowed by the single extra-wide lane, combined with a design that meant each successive layer of the ramp would take less time to build than the previous, meant no work stoppages on the pyramid.



In figure 21 we see pyramid level 36 is complete and work on level 37 has begun, even though the ramp is also under construction. Jean-Pierre Houdin's theory shows that by planning well in advance Hemienu could have kept work moving on the Great Pyramid even when the ramp was not available. It was a matter of being aware of the limitations of particular strategies and knowing how to adapt once these limits were met. The architect Houdin shows how the architect Hemienu, like a masterful chess player, would have thought out his strategy many moves in advance, with every outcome predetermined.



With layer 36 of the ramp complete, the pace of work on the pyramid can again shift into high gear. In Figure 22 we see that, as was the case in Figure 20, work on the current level is suspended while preparations for the following level are made. With about half of the core packed into place, a mini-ramp has been erected between levels 37 and 38 and the stockpiling of materials for level 38 has begun. Once sufficient building materials are stored to keep work on level 38 moving while the ramp is built up a layer, the workers will return their attention to finishing pyramid level 37.

With the alternating lane system now obsolete, Hemienu would have continued with this strategy until level 50 of the pyramid was finished and layer 50 of the external ramp was constructed. These achievements, along with the leveling of the core at 43 meters, would signal the end of Phase One. The external ramp would then be ready to transport the huge beams to be installed in Phase Two, the internal structures of the pyramid that would enable this feat would be complete, and the foundation for the King's Chamber would be set.

We have now laid out the basic concepts of how the external ramp worked with the pyramid, how this strategy was adapted when circumstances required a change of plan, and how and why the pyramid was built from the inside out. In *Phase One, Part 3*, we will take a brief look at the internal structures of the bottom third of the pyramid (or two thirds, if you are considering mass instead of height). After that we will be ready to proceed to *Phase Two: Building the King's Chamber*.